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TEXTILE RESEARCH JOURNAL

VOL. XVII, No. 4 April, 1947

Relation of Color Perception to Chemical Structure: A Critical Bibliography

I. H. Godlove*

Certain specialized bibliographies have appeared in previous issues of TEXTILE RESEARCH JOURNAL.† *These were prepared in accordance with a pattern established by the* JOURNAL *and each is intended to serve as a reference list of books and other primary references in a restricted field of inquiry.*

In this paper we have departed somewhat from our established pattern because of the fact that, as Dr. Godlove explains in his introductory discussion, so few books or summary reports exist in this field. Much of the information is available only in the periodical literature.

It is believed that this critical bibliography represents a distinct service to our readers and will be of great help to anyone who wishes to pursue the subject thoroughly.

Explanatory Introduction and Foreword

(Including the relation of this bibliography to the Nickerson bibliography on color)

If one defines *color* strictly, either (1) in the way it was defined by the Greeks of antiquity or (2) as it is defined by modern authoritative reports written by scientists, it may be said that there exist, as distinct entities, almost no complete works covering the field of color and chemical structure. The bulk of work in this field has been done by chemists and physicists interested primarily in the relation of absorption spectra to chemical structure, and only indirectly in the subject of our title. Originally, their interests made them approach chemical structure from color perception; later they approached structure from the reverse direction, through physical data. The reversal arose out of the belief in the higher precision of absorption-spectra measurements over visual observations and in the more "fundamental" nature, for their purposes, of correlations of the former with chemical structures. To call attention to the difference in these two general approaches (from visual observation and through spectra), the reviewer has frequently used quotation marks around "color" in the phrase "color and chemical structure," with the explanation that "color" is color, properly speaking, only in the sense that absorption spectra

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†Dyer, Agnes S., and Fischer, Earl K., "Selected References on Surface Chemistry and Physics," TEXTILE RESEARCH JOURNAL **15**, 362 (Oct. 1945); Nickerson, Dorothy, "Selected References Relating to the Field of Color Science," TEXTILE RESEARCH JOURNAL **16**, 74 (Feb. 1946).

("color") partially determine the color perception (as well as color in the technical sense indicated below).

Antiquity defined *color* to embrace what is now more precisely described by the terms *color sensation* and *color perception;* that is, roughly, "what we see" (except for certain spacial and temporal effects). As the term is now used by committees of scientists, of which the reviewer is a member, color consists of the characteristics of *light* other than spacial and temporal inhomogeneities. Light, for our purposes, is visually evaluated radiant energy; it is a "psychophysical" quantity and concept, neither purely physical (like energy radiating from the sun or a lamp and reflected from an object) nor purely perceptual ("psychological"). "Light" is not equivalent to radiant energy, or even to visual radiant energy; nor is "light" merely sensation, for it includes perceptual factors over and above the integration of the visual sensations. This aspect of our subject will not be

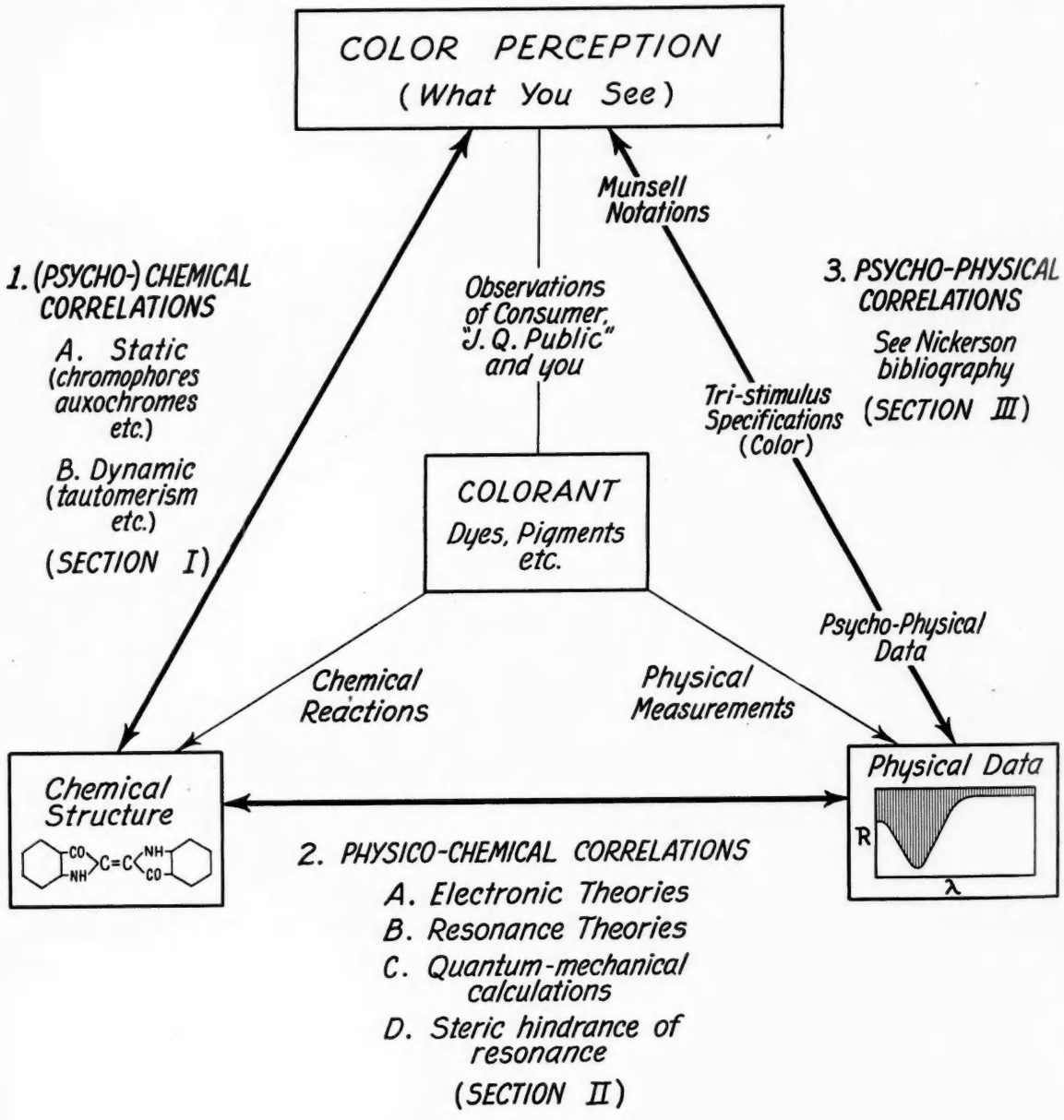

FIG. 1.

(*This triangle was suggested, in outline form, to the author by Dr. W. F. Busse.*)

discussed here or included in the bibliography, for it is adequately treated in the recent report of the Colorimetry Committee of the Optical Society of America, and in the other references in the bibliography of color compiled by Dorothy Nickerson in Textile Research Journal **16**, 74–83 (Feb. 1946).

However, to make the work of chemists in this field meaningful with respect to the relationship of color perception (not merely of physical data on absorption spectra, etc.) and chemical structure, the gap corresponding to most of the third side of the triangle schematized in Figure 1 must be filled with the data of psycho-physical correlations in the way given in the Nickerson references. Although it is true that many papers by chemists, as in the Waldron and Reid reference in section IA (page 190), deal directly with the relation of color perception to chemical structure, probably a much larger proportion deal with the relation of absorption spectra to structure. There is much confusion due to the implied or tacit assumption that *color* and *absorption spectra* are practically synonymous.

Furthermore, there is an almost universal tendency among chemists to focus attention upon one of the three aspects or variables of color perception; that is, upon hue, which they make almost synonymous with color. Only occasionally do they discuss, or even mention, such measures of absorption intensities as molecular extinction coefficients or oscillator strengths ("f values"), except to state them as empirical results. These correlate roughly with the dyer's and colorist's "brightness," which is a compound function of "saturation" (= chroma) and "lightness." ("Brightness" as used by the Optical Society of America embraces lightness only, but is a more general term than the latter, and different from the dyer's brightness.)

Under the name of Schütze, in section IA (page 190), a series of "colors" (properly "hues") is explicitly defined, each member "deeper" than the preceding one. This conception is very convenient if proper precautions are observed in its application, which is almost never done by chemists. In use, hue and color perception are confused, and this in spite of the fact that hue is only one of the three variables of color perception. Moreover, chemists reach a conception of "depth" primarily by looking at increasingly deeper layers of colored fluids, arriving at a sequence of concentrations for which all three variables of the color perception usually change (one after reaching a maximum and reversing). This conception is either explicitly or implicitly used by many chemists; it mars the work of many, as may be seen in the otherwise excellent work of Brooker (section IIB). The Schütze series is wrong in certain details, which will not be pointed out here. Moreover, it can be shown that, at least in the case of certain ideal absorption spectra of maximum saturation, a 5–10-mμ shift of absorption in the yellow hue range has more effect on the hue than a 50-mμ shift in the blue-green hue range. Consequently, correlations, such as Brooker's, of wave lengths of maximum absorption and chemical structure are not always valid as correlations of hue (or color perception) and structure. But Brooker's fine generalizations can be made valid in the latter sense if combined with the data of the Nickerson references previously mentioned, some of which refer to the work of Brooker's colleagues at the Kodak Research Laboratories.

The triangular relationship of color perception, chemical structure, and physical data (typified by absorption spectra) is shown schematically in Figure 1. One can correlate color perception with chemical structure either (a) by following directly along leg 1 of the triangle; or (b) indirectly by following along legs 2 and 3. The Arabic numbers do not all correspond exactly to the Roman numbers used in the classification of references, for we do not include the references given by Nickerson (leg 3), but must include a section on the junction of legs 2 and 3 (physical data: absorption spectra, section III). The three legs are labeled (1) ("psycho-) chemical," (2) "physico-chemical," and (3) "psycho-physical" correlations, respectively. The first part of the first term is enclosed in parentheses because the correlations are usually thought of as merely "chemical."

Section I (leg 1) includes two sub-sections: (A) predominantly "static" conceptions—theories of chromophores, auxochromes, salt-forming, color-intensifying groups, Nietzki's Rule, Schütze's series, etc.; and (B) predominantly "dynamic" conceptions—theories of tautomerism, oscillation of benzenoid and quinonoid linkages, isorropesis, etc. In general, the chronological order of development was from theories classifiable in (A) to those classifiable in (B) (and then to those in section II).

Section II (leg 2) includes four sub-sections, somewhat arbitrarily inclusive, especially because of overlap between parts (A) and (B). These sections are: (A) electronic theories; (B) resonance theories,

typified by consideration of resonance between various electronic structures, the "true" chemical structure or picture being a hybrid of these; (C) quantum-mechanical calculations of the parameters of absorption spectra (of "color" in the special sense) from assumed chemical and electronic structures; and (D) steric hindrance effects concerned with the inhibition of complete resonance by lack of coplanarity of two rings in the structures, or by other geometrical effects.

Section III (junction of legs 2 and 3) deals with the accumulations of physical data, restricted to consideration of absorption (and transmission and reflection) spectra only. The data with which the absorption data must be combined are the spectral (and spacial) distribution of radiant energy in the real or assumed source of illumination; and certain psycho-physical data involved in what is known today as the "1931 I. C. I. standard observer and coordinate system for colorimetry," given in the Nickerson references. By means of these data, we arrive at a "tristimulus specification" of the color for the standard (hopefully, average normal) person, "color" now being used in the technical psycho-physical sense defined above. From this specification, by means of references also given by Nickerson, we arrive at a quasi-psychological specification, that of the Munsell system of colors.

Section IV (leg 3) logically comprises the data, just mentioned, given in the Nickerson references, the psycho-physical data. It might be termed "the Gap" in many discussions of the (indirectly considered) relation of color to chemical structure, which travels in part along leg 2 and makes use of the precision inherent in measurements of absorption spectra. Unless the psycho-physical data of section IV (leg 3) are included, precision cannot possibly be converted into accuracy.

I. (Psycho-)Chemical Correlations

A. Static Theories

1. Armstrong, H. E. *Philos. Mag.* **23**, 73 (1887); *Proc. Chem. Soc.* **1888**, 27–33.

Outlines the "quinonoid theory" of the cause of color. (Developed further by E. and O. Fischer in 1900.)

2. Baeyer, von, A. *Ber. deut. chem. Ges.* **18**, 2277 (1885).

Develops the "strain theory," much used later by others; according to this a chemical bond tends to lie in a straight line joining atom to atom, and the directions of the four bonds emanating from a single carbon atom are those determined by a tetrahedral symmetry. Whenever the bonds are forced out of these positions there is a state of strain which manifests itself through instability and unsaturation. Among rings, those of five or six atoms produce least strain.

3. Baeyer, von, A., in a series of papers in *Ber. deut. chem. Ges.* and J. Liebig's *Ann. d. Chem.* from 1902 to 1907.

Stresses the importance of salt formation and develops a theory of "halochromy" (salt color) as a result largely of work on triphenyl-methane dyes; salts exist as isomers, one with ionizable basic methane carbon ("carbonium-valence theory"). The quinonoid group does not always produce color.

4. Dilthey, W. *J. prakt. Chem.* **109**, 273–323 (1925).

The most powerful absorbers of visible light are "ionoid"; this idea was developed later by Wizinger.

5. Fischer, E., and Fischer, O. *Ber. deut. chem. Ges.* **11**, 191, 612–3 (1878); **12**, 796–803, 2344–53 (1879).

The classical work on the triphenyl-methane dyes; a para-quinoid structure is given to parafuchsin, etc.

6. Funkhouser, J. A., and Brode, W. R. *J. Am. Chem. Soc.* **56**, 2172–3 (1934).

Influence of chromophore position in disazo dyes.

7. Gillam, A. E., and Hey, D. H. *J. Chem. Soc.* **1939**, 1170–77.

In para-coupled polyphenyls, the maximum absorption is shifted to longer wave lengths on increase of chain length, but not in meta-coupled.

8. Gomberg, M. *J. Am. Chem. Soc.* **22**, 757–71 (1900); *Ber. deut. chem. Ges.* **33**, 3150–63 (1900).

Discovery of triphenyl methyl, a colored "free radical" containing no double bond (ordinary unsaturation center), causing a drastic revision of current theory.

9. Gräbe, C., and Liebermann, C. *Ber. deut. chem. Ges.* **1**, 106–8 (1868).

First studies of the relation of "color" to chemical structure. Pointed out that generally reduction of colored compounds produces colorless ones (exceptions found by R. Scholl, 1903–8). Stressed the importance of unsaturation and emphasized the importance of "quinonoid" structure.

10. Hewitt, J. T., and Mitchell, H. V. *J. Chem. Soc.* **91**, 1251–66 (1907).

Stressed the importance of conjugated chains of atoms. "Hewitt's Rule" is that the longer the chain the "deeper" the color (later corrected by Brooker and others).

11. Kauffmann, H., *et al. Z. Farben-Ind.* **5**, 417–21 (1906); *Ber. deut. chem. Ges.* **39**, 1959–66, 2722–6 (1906); **40**, 843–6, 2338–40, 2341–52, 2352–8 (1907); **41**, 4413–22 (1908); "Die Auxochrome," Ahrens' *Sammlung* **12**, 1–3 (1907).

Especially the first and last references are important. The first summarizes the work on the relation of color and chemical structure up to 1906; in his "auxochrome theory," adopting Thiele's theory of "partial valencies," the author defines auxochromes as groups which require more than one whole valence of the benzene ring; on this basis he works out many relations of color and structure. Finds the effect of the auxochrome greatest when there is a benzene ring between it and the chromophore; direct action of chromophore and auxochrome sometimes destroys color. Finds two chromophores most effective when in the para-position with respect to each other; their effect nil when in meta-position; Hantzsch's principle (see section IB) is contradicted; stresses chromophores without double linkages.

12. König, W. *J. prakt. Chem.* **112**, 1–36 (1926); *Z. wiss. Phot.* **34**, 15–39 (1935); see also König, W., *et al., Ber. deut. chem. Ges.* **58**, 2559–66 (1925); **61**, 2074–80 (1928).

Distinguishes "mesochrome" (conjugated chain) and "perichrome" groups (terminal nuclei) in dye molecules; developed also by J. D. Kendall in 1926.

13. Nietzki, R. *Verhandl. des Vereins zum Beförderung des Gewerbfleisses* **58**, 231 (1879).

Develops Nietzki's Rule, that increase of molecular weight (by methylating, ethylating, or phenylating) leads to "deeper" colors (see Schütze).

14. Norris, J. F., and Sanders, W. W. *J. Am. Chem.* **25**, 54–62, 117 (1901); and, independently, Kehrmann, F., and Wentzel, F., *Ber. deut. chem. Ges.* **34**, 3815–9 (1901).

Assume the existence of colored and colorless isomers of triphenyl-methyl salts, the colored form with "basic carbon" and quinol structure.

15. Pfeiffer, P. J. Liebig's *Ann. d. Chem.* **376**, 285–310 (1910); **383**, 92–155 (1911); **404**, 1–20 (1914); **412**, 253–335 (1916); see *Brit. Chem. Abstracts* **1910**, i, 852; **1911**, i, 788; **1914**, i, 551; **1917**, i, 205; "Organische Molekülverbindungen," Stuttgart, F. Enke, 1927.

Uses additive carbonyl-inorganic compounds and Thiele's partial-valence theory to explain Gräbe and Liebermann's Rule and that the formation of molecular compounds increases color. Halochromic compounds (these addition compounds, the nitro-compounds, and quinhydrones) have their increased color referred to this one-sided distribution of unsaturation. Triphenyl methyl contains a monatomic chromophore atom; C–C, N–N, etc. are doubled chromophores.

16. Piper, J. D., and Brode, W. R. *J. Am. Chem. Soc.* **57**, 135–8 (1935).

In disazo dyes, when two chromophores are sufficiently separated they absorb independently; when conjugated or closely linked they show marked de-

viations from additive absorptions. (See also Ramart-Lucas, P., *Bull. soc. chim.* **51**, 289–338 (1932)).

17. Scholl, R. *Ber. deut. chem. Ges.* **36**, 3410–26 (1903).

If chromogens having more than one chromophore are reduced in such a way that one part of the chromophores remains while the other goes over into an auxochrome group, color deepening may result, contradicting Gräbe and Liebermann's Rule.

18. Schütze, M. *Z. physik. Chem.* **9**, 109–36 (1892).

Shows exceptions to Nietzki's Rule and states other rules; the "Schütze series" is explicitly defined as one of increasingly "deep" colors (hues), as still (incorrectly) used by chemists: yellow, orange, red, purple, violet, blue, and green.

19. Sherndal, A. E. *J. Am. Chem. Soc.* **37**, 167–71, 1537–44 (1915).

Discovery of the blue hydrocarbon, azulene, the first colored one.

20. Waldron, W. R., and Reid, E. E. *J. Am. Chem. Soc.* **45**, 2399–2417 (1923).

A rather complete study of the effect of sulfur-containing chromophores and auxochromes on the color of azo dyes.

21. Willstätter, R., *et al. Ber. deut. chem. Ges.* **37**, 1494–1507, 4605–9, 4744–6 (1904).

Discovery of the unexpectedly colorless quinone imines, imino-quinone and di-imino-quinone, parent compounds of many dyes, and (last paper) of red ortho-benzoquinone.

22. Witt, O. N. *Ber. deut. chem. Ges.* **9**, 522–7 (1876); **21**, 321–5 (1888).

This outlines the first well-defined theory of color which is the classic one today; it hinges around the (static) presence of "chromophore" groups, often a conjugated chain of atoms, and "auxochrome" groups (NH_2, OH, etc.), which "deepen" the color, as well as salt-forming groups.

23. Wizinger, R. *Z. angew. Chem.* **39**, 564 (1926); **40**, 503–4 (1927); *Ber. deut. chem. Ges.* **60**, 1377–89 (1927); "Organische Farbstoffe," Berlin, Ferd. Dümmlers Verlag, 1933.

This book is a very well organized small one classifying dyes and chromophores from the standpoint of the positive-negative auxochrome, or auxochrome-antiauxochrome, theory of Dilthey. This theory does not take into account the phenomenon of resonance, and it does not lend itself to quantitative treatment.

B. Dynamic Theories

24. Baeyer, von, A. J. Liebig's *Ann. d. Chem.* **354**, 152–204 (1907).

Develops a theory of the oscillation of quinonoid linkages between benzene nuclei in the triphenylmethane dyes (also independently by A. Green, 1909); atomic vibrations, as of a chlorine atom in Döbner's violet or of a sodium atom in benzaurine, from one position to another in the molecule, lead to color. This theory was put into electronic form by E. Q. Adams and into modern resonance form by Bury.

25. Baly, E. C. C., Desch, C. H., and Stewart, A. W. *J. Chem. Soc.* **85**, 1029–41 (1904); **87**, 766–84 (1905); **89**, 489–501, 502–14, 514–30, 618–31 (1906); **91**, 426–35, 1572–84 (1907); *Proc. Chem. Soc.* **22**, 33–5 (1906).

Stresses the importance of the production of absorption bands by tautomeric change (the change itself causing "color"); and develops a theory of "isorropesis," a recurrent making and breaking of valence linkages, to explain color production in unsaturated compounds.

26. Baly, E. C. C. *Astrophys. J.* **42**, 4–71 (1915); *J. Soc. Dyers and Colourists* **31**, 39–46 (1915); *J. Soc. Chem. Ind.* **34**, 393–9 (1915); *J. Chem. Soc.* **107**, 1121–32 (1915); *Philos. Mag.* 27, 632–43 (1914).

Attacks the quinonoid theory of "color," which breaks down in certain cases; stresses intermediate

stages in chemical reactions; theory that color is due to "opening up of the fields of force" emanating from secondary valence electrons; the frequencies of absorption and fluorescence bands are simple multiples of a fundamental frequency in the near infrared.

27. Curtiss, R. S. *J. Am. Chem. Soc.* **32**, 795–809 (1910).

A good summary, from the viewpoint of an organic chemist, of the literature and development of theory of color and chemical structure up to 1910.

28. Hantzsch, A., in papers published from 1906 to 1916, especially in *Ber. deut. chem. Ges.*

States the belief that "every appearance of, or change of, color of a compound in salt formation with colorless metal atoms is to be ascribed to an intramolecular rearrangement"; this phenomenon, proved in the case of methyl orange, is called "chromotropy," and the isomeric substances, "chromoisomers." In papers from 1899 to 1908 in *Ber. deut. chem. Ges.*, Hantzsch develops a theory of rearrangement of colorless "pseudo-acids" to colored compounds. For reviews of the ideas and work of Hantzsch, see Getman, F. H., *J. Phys. Chem.* **26**, 221 (1922); and Moore, T. S., *J. Chem. Soc.* **1936**, 1060–66.

29. Hartley, W. N. *J. Chem. Soc.* **51**, 152–61 (1887).

Develops a theory of the increase in amplitude and modulation (dampening) of atomic vibrations of parent compounds (dye intermediates, absorbing in the ultraviolet) by the introduction of chromophores and auxochromes.

30. Henrich, F. "Theories of Organic Chemistry," translated by Johnson and Hahn, New York, John Wiley & Sons, 1922 (German 5th edition, 1925), chapter XVI.

A thorough treatment, like Watson's book, of the relation of color and chemical structure, from the older, pre-electronic and pre-resonance point of view.

31. Scheibe, G. *Kolloid-Z.* **82**, 1–14 (1938); *Angew. Chem.* **52**, 631–7 (1939).

Shows that reversible polymerization is responsible for new bands in dyes; see also Jelley, E. E., *Nature* **138**, 1009–10 (1936); **139**, 631 (1937).

32. Sheppard, S. E. *Rev. Modern Phys.* **14**, 303–40 (1942). See also Sheppard and Geddes, A. L., *J. Am. Chem. Soc.* **66**, 1995–2009 (1944).

A fine summary and critical review of the effects of environment (solvents, etc.) and aggregation on the absorption spectra of dyes.

33. Stieglitz, J. (1923–5). See section IIA.

34. Stieglitz, J., and Acree, S. F. *J. Am. Chem. Soc.* **39**, 402–31, 528–44, 649–53 (1908).

Show that the interaction of a quinoid structure with phenol groups produces a strong chromophore (a quinhydrone); authors develop a "quinhydrone theory" of color production; see also Green, A., *J. Soc. Chem. Ind.* **28**, 638 (1909).

35. Watson, E. R. *J. Chem. Soc.* **105**, 759–67 (1914).

States that to obtain intense colors, tautomerism must occur and the conjugated chain must be contained in a quinonoid formula in all possible tautomeric forms.

36. Watson, E. R. "Colour in Relation to Chemical Constitution," London, Longsman, Green & Co., 1918.

This is an excellent pre-electronic and pre-resonance study of the relation of absorption spectra and color to chemical structure; it is thorough and well written, but of course covers only the older literature. It gives several theories of waves of atomic vibrations, passing from one end to the other of dye molecules, to account for color.

37. Watson, E. R., and Meek, D. B. *J. Chem. Soc.* **107**, 1567–78 (1915).

States that the main absorption band is due to reversal of the conjugated chain during tautomeric change; the color is "deeper" the longer the conjugated chain thus reversed.

38. Willstätter, R., and Piccard, J. *Ber. deut. chem. Ges.* **41**, 1458–75 (1908).

Deals a blow at the quinonoid theory of color production by showing that the division of groups into chromophores and auxochromes is arbitrary; and that certain simple compounds containing the quinonoid group are colorless or feebly colored, auxochromes being required to develop the color; develops a theory of "meriquinoid-holoquinoid" isomerism with isorropesis.

II. Physico-Chemical Correlations

A. Electronic Theories

39. Adams, E. Q., and Rosenstein, L. *J. Am. Chem. Soc.* **36**, 1452–73 (1914).

This is the first paper which gave lucid arguments to show that it is not the vibration of atoms but the oscillations of electrons which are responsible for intense absorption (and color) in dyes; the color changes in certain triphenyl-methane dyes are comprehensively treated.

40. Burawoy, A. *J. Chem. Soc.* **1937**, 1865–9; **1939**, 1177–88.

Burawoy is the outstanding unorthodox worker in this field; he develops theories of absorption on the basis of "electron isomerism," which is not parallel to resonance, and classifies chromophores as "radical" (R) and "conjugation" (K) chromophores, attributing certain absorption bands to each.

41. Campbell, N. R. "Modern Electrical Theory," Cambridge, England, Cambridge University Press, 1913–23, pp. 315–16.

First recognizes that the oscillating components of dye molecules which cause absorption bands must be electrons, not atoms (though earlier calculations of the number and mass of particles causing absorption had been made by Drude and by Erfle).

42. Stark, J. "Prinzipien der Atomdynamik," Leipzig, S. Hirzel, 1911; *Z. Elektrochem.* **17**, 514–7 (1911).

Absorption of light is said to be due to loosened electrons in aromatic nuclei and in chromophores.

43. Stieglitz, J. *Proc. Natl. Acad. Sci.* **9**, 303–8, 308–12 (1923); *J. Franklin Inst.* **200**, 35–49 (1925).

Develops a theory that color production is due to an intra-molecular oxidation-reduction process, leading to vibrations of electrons and visible absorption. Many of the ideas of this theory can be dressed in modern garb and taken over into present-day theories.

B. Resonance Theories

44. Arndt, F., *et al. Ber. deut. chem. Ges.* **57**, 1903–11 (1924); **63**, 587–96, 2963–6 (1930).

Develop a theory of "intermediate stages" in chemical reactions which is a transition to resonance theory.

45. Branch, G. E. K., and Calvin, M. "The Theory of Organic Chemistry," New York, Prentice-Hall, 1945; chapter V, sect. 20, pp. 155–82 ("Color").

This is an excellent, though brief, treatment. It hinges around the general "color" theory of Lewis and Calvin which correlates absorption spectra (not color) and chemical structure. But besides the "color" section, other chapters give background material for a better understanding of the relation of spectra and structure.

46. Brooker, L. G. S. *Rev. Modern Phys.* **14**, 275–93 (1942); "Resonance and Organic Chemistry," part IV, pp. 63–136, of "Advances in Nuclear Chemistry and Theoretical Organic Chemistry," edited by R. E. Burk and O. Grummitt, New York, Interscience Publishers, 1945.

The latter treatment is an elaboration of the former, earlier, treatment, although, as the title indi-

cates, the latter is broader in scope. In both, the relation of absorption spectra, rather than color, to structure is treated in a masterly and lucid fashion. In part I of the second reference, after a brief résumé of classical chemical structural theory, the resonance theory is introduced. After the theory for the simple case of hydrogen is given, it is extended to more complex molecules, including benzene and its reduction products, and to dyes. There are included brief treatments of the relation of resonance theory to the orienting influence of substituents in the benzene ring, to the strengths of acids and bases, and to dipole moments.

In part II, the resonance theory is applied to the problem of "color" (absorption spectra) and chemical structure. After brief remarks on absorption in general, and on the Witt chromophore-auxochrome theory, the latter is interpreted in terms of the resonance theory and important "auxochromophoric" systems are discussed. From here on many rules are developed regarding the wave-length position of absorption bands resulting from various dye structures; and the data for these correlations come very largely from the excellent and extensive work done on various series of dyes, especially sensitizing dyes, in the Kodak laboratories under Brooker's direction. Whereas Remick sets up explicitly 29 "Basic Principles," many of which serve to outline the resonance theory, and one of which is: "Other things being equal, the most stable resonance form will have the greatest number of covalent bonds," Brooker treats at some length the "additional-double-bond stabilization" conferred on certain cyclic dye structures. This is an important factor, as are factors of symmetry.

Brooker's 1942 treatment, fine though it was, suffered from certain defects: (1) His rules relate structure differences to wave length of maximum absorption, and changes in the latter; but this correlates with only one of the three variables of color; (2) little is said about intensities of absorption, which correlate to some extent with a second variable of color; (3) in the proper sense, the whole treatment stopped short of color, for it really correlated only chemical structure and the parameters of absorption spectra; (4) Brooker preserves the Schütze definition of "depth" of color, which is inadequate in several particulars; and (5) his rules correlate chemical differences with wave-length changes; but a wave-length change of 5 to 10 mμ in one range (the yellow) may produce more color (hue) change than a 50-mμ change in another range (say blue-green).

Turning to some detail, Brooker stresses the importance of the "degeneracy" or non-degeneracy of the extreme resonance structures of dyes resulting from the symmetrical state due to identical or non-identical terminal groups. When comparing the wave length of maximum absorption of an asymmetrical dye with the mean of the corresponding wave lengths of the corresponding symmetrical ones, the greater the imbalance of basicity in the two halves, the greater the deviation from the mean. In series of dyes of similar structure but increasing chain length, Hewitt's Rule (see section IA) is not followed; the wave lengths tend to converge, with increasing chain length, when the extreme resonance structures are not identical, and tend to be non-convergent when they are identical. Some series contradict the general impression that "the greater the resonance, the deeper the color."

47. Bury, C. R. *J. Am. Chem. Soc.* **57**, 2115–7 (1935).

The first paper which applied the modern resonance theory to dyes. Intense absorption of light is shown to be due to an intimate association of a chromophore (often a conjugated chain) and resonance. The conjugated chain usually furnishes the path for resonance. Auxochromes introduce the possibility of resonance.

48. Hodgson, H. H., *et al.* Many papers from 1926 to the present date in *J. Chem. Soc.*, and *J. Soc. Dyers and Colourists.*

These papers give applications of modern electronic and resonance theory to the color and properties of dyes and dye intermediates.

49. Ingold, C. K., *et al. Chem. Rev.* **15**, 225–74 (1934).

Here are given references to many earlier papers on the electronic and resonance theories, broadly, without specific reference to color theory.

50. Leermakers, J. A., and Weissberger, A., in H. Gilman's "Organic Chemistry," New York, John Wiley & Sons, 1943; chapter 23, pp. 1783–94.

This is a good but brief treatment of "visible and ultra-violet spectra" from the modern standpoint.

51. Lewis, G. N. *J. Am. Chem. Soc.* **38**, 762–85 (1916).

Color is the result of selective absorption of light waves by valence electrons whose frequencies synchronize with light of definite frequency. The color seen is complementary to that of the absorbed light. Most molecules have electronic absorption bands in the ultraviolet only. If they contain chromophores, the absorption is in the visible spectrum. Auxochromes move the absorption toward longer wave lengths. Typical chromophores contain double bonds or other points of unsaturation. With unsaturation present, the forces between the nuclei and electrons are weakened; for a covalent double bond has two pairs of electrons, and both pairs cannot occupy positions of maximum stability. The characteristic frequency of an oscillating particle depends on the magnitude of the constraints and the mass of the particle. Electrons have small mass and (ordinarily) rigid constraints, and hence absorb at higher frequencies than atomic nuclei. Changes causing slight weakening of constraints lead to violet absorption (yellow color); more pronounced changes lead to absorption at longer wave lengths, finally giving blues and blue-greens. Large (aryl) groups introduced into ethylene, for example, finally cause the double bond to be so strained that the molecule dissociates and free radicals are formed; these have unpaired electrons which are loosely held. Hence the free radicals are generally colored; so also are all organic and inorganic molecules in which there is an odd number of electrons (loosely held), except in NO. Looseness of electronic constraints leads to three parallel phenomena: (1) color; (2) polar nature; and (3) tautomerism (which is parallel to but not the "cause" of color). Among the halogens, with an even number of electrons, the constraints, as judged by chemical evidence, are weakest in iodine, strongest in fluorine; iodine is deeply colored (violet), fluorine, pale yellow. The part of the molecule with electrons responsible for visible absorption is always highly polar and reactive, and there is great opportunity for free transition from one limiting (tautomeric) form to another. In 1916, Lewis believed that the process might consist "chiefly in the movement of electrons"; according to modern theory, it may be wholly the oscillation of electrons (resonance). See also *Proc. Natl. Acad. Sci.* **2**, 586–92 (1916).

52. Lewis, G. N. "Valence and the Structure of Atoms and Molecules," New York, Chemical Catalog Co., 1923.

Here Lewis repeats and elaborates upon his 1916 paper. On page 61, a distinction is made between colored substances, like ferrous iron, which undergo oxidation in single valence steps, and colorless ones, oxidized in steps of two. On page 80, odd molecules, including Gomberg's and Wieland's free radicals, are discussed; they are highly paramagnetic, and ionize in polar solvents. On page 89, it is stated that the properties of unsaturated organic compounds, many of them colored, have proved to be in good accord with the strain theory of Baeyer. On pages 92–3 and 153, conjugation of double bonds is discussed. On pages 159–62, it is pointed out that electrons are held tightly in the lower energy levels (of quantum theory) and loosely in the higher levels. When a molecule is in such a state that it may be changed to another state by a quantity of energy which, when divided by the Planck constant *h*, gives a number corresponding to the frequency of visible light, the substance is colored. Among the colored compounds of the elements of variable valency (Cr, Mn, etc.) and highly unsaturated compounds, the energy differences are small.

53. Lewis, G. N., *et al. J. Am. Chem. Soc.* **61**, 1894–1900 (1939); **62**, 2973–80, 3529 (1940); **63**, 3005–18, 3232–3 (1941); **64**, 1774–82, 2801–8, 2808–10 (1942); **65**, 520–6, 1144–50, 1150–4, 2102–6, 2107–10, 2419–23 (1943); **66**, 1579–83, 2100–16 (1944); **67**, 770–5, 994–1003, 1232–3 (1945).

Develops in detail the theory of the following reference, classifies absorption spectra and shows the effect on them of added acid, basic and amphoteric substances, isomerism, and polymerization.

54. Lewis, G. N., and Calvin, M. *Chem. Rev.* **25**, 273–328 (1939).

This review has become almost the classical one of modern viewpoint dealing with the relation of chemical structure and absorption spectra. It is one of the few "must" reading references in the field. However, it is so well and thoroughly abstracted in Branch and Calvin's book, and especially in Remick's book (see this section), that there is no reason to do it here.

55. Lewis, G. N., and Seaborg, G. T. *J. Am. Chem. Soc.* **61**, 1886–94 (1939).

Boron chloride, a "generalized acid," is found to have the same effect as concentrated sulfuric acid on the absorption spectra of polyenes. This fact is an important one in the theory of halochromy (color on salt formation); and with it Lewis takes issue with the theory of Dilthey, according to whom the most powerful absorbers of light are "ionoid."

56. Morton, R. A., *et al.* See section III.

57. Pauling, L. *Proc. Natl. Acad. Sci.* **25**, 577–82 (1939).

Develops a theory of the "color" of dyes; stresses the importance of intermediate as well as the extreme resonance states of dyes: the possibility of an electron moving in one jump from one end of a long conjugated chain to the other, is vanishingly small; the jumps may be shorter, giving intermediate steps, which often are carbonium valence structures. According to the theory, the absorption band of longest wave length is the most intense. In his book, "The Nature of the Chemical Bond," Cornell University Press, 2nd ed. (1940), and in his research papers, Pauling largely initiated the application of resonance theory to chemical problems.

58. Pauling, L., in H. Gilman's "Organic Chemistry," New York, John Wiley & Sons, 1943, 2nd ed., vol. II, chapter 26.

On page 1982, the question of intense colors is discussed in a closely knit argument.

59. Remick, A. E. "Electronic Interpretations of Organic Chemistry," New York, John Wiley & Sons, 1943, section "Resonance and the Color Theory," pp. 173–87.

This is the best short general review in English of the relation of absorption spectra to chemical structure known to the present reviewer. There is an excellent synthesis of the historical point of view with a perspective view of the present status of the subject. After a brief discussion of the classical chromophore-auxochrome theory, there are introduced the modifications resulting from the theories of Stieglitz, Dilthey-Wizinger, Schwartzenbach, Lewis and Calvin, Bury, and others. Although stressing the importance of resonance, Remick cites the warning of G. N. Lewis that increased resonance does not necessarily mean "deeper" color; and he explains the restrictions, mentioned by Lewis, in lucid fashion. The book contains also several chapters and appendices which give an exposition of the background for the study of the relation of color and chemical structure. See further certain remarks in the reference to Brooker's treatments (reference 46, second paragraph).

60. Reynolds, W. B. *Am. Dyestuff Reptr.* **32**, 455–6, 465–7 (1943).

States that "the mathematical treatment of resonance is simply the application of quantum mechanics to concepts of the structure of organic molecules that have been developing (empirically) among organic chemists for many years"; and the correlation of the empirical and resonance methods is excellent. In azo dyes, bases and coupling components can be arranged in an order of "inherent depth" ("depth" defined in the Schütze sense, section IA) imparted to the dye molecules; "color" is a summated effect if there are insulating groups between the parts; if not, the color is deeper than that due to simple addition.

61. Schwarzenbach, G., *et al.* *Helv. Chim. Acta* **20**, 490–8, 498–513, 627–33, 654–8, 1591 (1937).

Dyes are regarded as resonance systems in which two or more groups with free electron pairs (auxochromes) are attached to an unsaturated carbon residue (chromophore) in such a way that the double bonds can be displaced without appreciable effect on the stability of the molecule. The color changes of indicators are due to change from symmetrical to asymmetrical resonance, and vice versa. Gives many examples illustrating the correlation of the predicted influence of symmetry on resonance and its effect on "depth" of color.

62. Wheland, G. W. "The Theory of Resonance and Its Application to Organic Chemistry," New

York, John Wiley & Sons, 1944, chapter 6, "Resonance and Molecular Spectra."

A good treatment, very similar to those of Remick and Branch and Calvin; there are also excellent "background" chapters here, too, as in those works. On pages 149 and 158, there is some discussion of intensity of absorption; the amount of space devoted to this aspect of absorption spectra, though little enough, is more than that devoted to it by the other authors of reviews. For this aspect see the papers of Mulliken and Sklar.

C. Quantum-Mechanical Calculations of "Color"

63. Förster, T. *Z. physik. Chem.* **B41**, 287–306 (1938); **B47**, 245–68 (1940); *Z. Elektrochem.* **45**, 548–73 (1939).

Quantum-mechanical calculations on the theory of colored organic compounds.

64. Herzfeld, K., and Sklar, A. L. *Rev. Modern Phys.* **14**, 294–302 (1942).

A very interesting paper in which, from quantum-mechanical calculations on the basis of certain plausible assumptions, predictions are made of some of the generalizations found empirically by Brooker and his coworkers; the predictions hinge around an equation derived by them. See also Herzfeld, *J. Chem. Phys.* **10**, 508–20 (1942), and Sklar, *J. Chem. Phys.* **10**, 521–31 (1942).

65. Hückel, E. *Z. Physik* **70**, 204–86 (1931); **72**, 310–37 (1931).

Quantum-mechanical calculations on the absorption spectra of benzene derivatives.

66. Lennard-Jones, J. E., *et al. Proc. Royal Soc.* **A158**, 280–96, 297–305 (1937).

Molecular resonance is treated as a problem in wave mechanics leading to calculations of the "color" of compounds; the concept of "mobile electrons" is introduced.

67. Mulliken, R. S. *Rev. Modern Phys.* **14**, 265–74 (1942).

Discusses the absorption spectra of ethylene derivatives from the quantum-mechanical point of view.

68. Mulliken, R. S. *J. Chem. Phys.* **7**, 14–20, 20–34, 121–35 (1939); Mulliken, R. S., and Rieke, C. A., *Reports on the Progress of Physics* 8, 231–73 (1941).

These papers deal, among other things, with quantum-mechanical calculations of intensities of absorption, as measured by extinction coefficients and oscillator strengths.

69. Mulliken, R. S., Rieke, C. A., and Brown, W. G. *J. Am. Chem. Soc.* **63**, 41–56 (1941).

Discusses the effects of "hyperconjugation," which had been treated by G. W. Wheland (1934) and by J. W. Baker, *et al.* (1935, 1942); bathochromic shift of absorption spectra (to longer wave lengths) due to introduction of alkyl groups is due to interaction between electrons of the ring structure and those involved in the C–H links of the alkyls.

70. Sklar, A. L. *J. Chem. Phys.* **5**, 669–81 (1937); **7**, 984–93 (1939); **10**, 135–44, 521–31 (1942); *Rev. Modern Phys.* **14**, 232–45 (1942).

Gives quantum-mechanical calculations of absorption spectra of substituted benzene derivatives; energy levels are given in terms of a parameter "alpha" which can be determined from heats of hydrogenation; the last reference is a fine review, lucidly written, showing the relative effects of substitution by methyl, amino, hydroxyl, and fluorine groups, including absorption intensities.

D. Steric Hindrance of Resonance (a few examples only)

71. Pickett, L. W., Walter, G. F., and France, H. *J. Am. Chem. Soc.* **58**, 2296–9 (1936).

Steric inhibition of resonance by large substituent groups prevents the formation of conjugation absorption bands in biphenyl derivatives by forcing the two rings into different planes; a planar structure is required for the mobile electrons to have maximum effect.

72. Rodebush, W. H., *et al.* *J. Am. Chem. Soc.* **62**, 2906–11 (1940); **63**, 3018–25 (1941); examples of steric inhibition of resonance and its effect on color. See also Müller, E., and Neuhoff, H. *Ber. deut. chem. Ges.* **72**, 2063 (1939); Jones, R. N., *J. Am. Chem. Soc.* **63**, 1658 (1941); Wheland's book (reference 62), pp. 160–2.

III. The Physical Data (Absorption Spectra)

In this section are listed a number of references which give, along with theoretical discussions, tabulated or plotted data on absorption spectra of organic substances, especially in the form of values of wave length of maximum absorption and molecular extinction coefficients or oscillator strengths ("f" values).

73. Arnold, L. B., and Kistiakowsky, G. B. *J. Am. Chem. Soc.* **54**, 1713–22 (1932).

Illustrates how the absorptions due to phenyl and carbonyl groups are modified by interaction between them when near each other, and how the effects of the interaction diminish as the groups are separated by inert ("insulating") groups.

74. Baly, E. C. C., and Stewart, A. W., *et al.* *Proc. British Assoc. Advanc. Sci.* **1916**, 131; **1920**, 244; **1922**, 294; **1928**, 341.

A list of compounds whose absorption spectra have been studied (through 1927).

75. Beilenson, B., Fisher, N. I., and Hamer, F. M. *Proc. Royal Soc.* **A163**, 138–55 (1937).

Authors discovered that in many cases the main absorption band of unsymmetrical dyes occurs at a frequency which is the mean of the characteristic frequencies of the parent symmetrical dyes of which the unsymmetrical dye may be considered a cross. See also reference 79.

76. Carr, E. P., and Sherrill, M. L., in "International Critical Tables," New York, McGraw-Hill, 1929, vol. V, p. 326.

Bibliography of absorption spectra of about 3,300 compounds.

77. Chako, N. Q. *J. Chem. Phys.* **2**, 644–53 (1934).

A survey of data on wave lengths of maximum absorption of organic compounds and a derivation of the elementary mathematics of absorption.

78. Clar, E. *Ber. deut. chem. Ges.* **69**, 607–14 (1936); **73**, 81–6, 596–606 (1940).

Develops numerical relationships from which we can predict the absorption spectrum of highly condensed, reactive, linear, quinone-forming hydrocarbons, such as deep-blue pentacene and deep-green hexacene.

79. Fisher, N. I., and Hamer, F. M. *Proc. Royal Soc.* **A154**, 703–23 (1936).

An important paper on the absorption spectra of symmetrical cyanine dyes. See also Beilenson, Fisher, and Hamer (reference 75).

80. Formanek, J. "Qualitative Spektralanalyse anorganischer Körper und Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischen Wege," Berlin, Julius Springer, 1900, 1908, and 1926.

Gives, in a qualitative and semi-quantitative way, the absorption spectra of many compounds, especially of dyes.

81. Gillam, A. E., *et al.* *J. Chem. Soc.* **1939**, 1170–7; **1941**, 364–7, 815–20.

Absorption data on chains of benzene nuclei, phenyl pyridines, unsaturated ketones, etc.

82. Hausser, K. W., Kuhn, R., *et al.* *Z. physik. Chem.* **B29**, 363–70, 371–7, 378–83, 384–9, 391–416, 417–54 (1935).

These papers, now almost classical, give the absorption spectra of the important series of polyenes, furanes, compounds with various end-groups joined

by varying numbers of vinylene groups, and of other conjugated compounds; see Smakula (reference 93).

83. Henri, V. "Structure des molecules," J. Hermann, editor, Paris, Soc. chim. phys. 1925.

Gives ultraviolet absorption data on many benzene derivatives.

84. Holmes, W. C. in "International Critical Tables," New York, McGraw-Hill, 1930, vol. VII, p. 173.

Absorption data and bibliography, including Holmes' own numerous papers, on over two thousand dyes and pigments.

85. Jones, R. N. *Chem. Rev.* **32**, 1–46 (1943); *J. Am. Chem. Soc.* **67**, 2127–50 (1945).

Gives a survey of the ultraviolet absorption spectra of hydrocarbons. In the latter paper especially, the effects of chemical structure on spectra are classified as "bathochromic," "fine structure," "conjugation," and "steric effects."

86. Lasareff, P. P., and Nedopekin, P. M. "Atlas des spectres des substances colorantes," Leningrad, Académie des Sciences, 1927.

Gives the absorption spectra of 746 dyes.

87. McMurray, H. L. *J. Chem. Phys.* **9**, 231–40, 241–51 (1941).

A critical survey of the absorption data on aldehydes and ketones.

88. Morton, R. A., *et al.* *J. Chem. Soc.* **1934**, 883–901, 901–11, 911–16, 916–30; **1939**, 1321–4; **1940**, 1347–59; **1941**, 159–69; *Ann. Repts. on the Progress of Chem., Chem. Soc.* **38**, 7–27 (1942) (report for 1941); and other papers.

Critical surveys of absorption data on many classes of organic compounds.

89. Mulliken, R. S. See section IIC.

90. Pestemer, M., and Mayer-Pitsch, E. *Monatshefte* **70**, 104–12 (1937).

Gives data on the absorption spectra of biphenyl derivatives.

91. Rabinowitch, E. *Rev. Modern Phys.* **14**, 112–31 (1942).

Summarizes in an excellent manner the data on the absorption spectra of crystals and of anions, cations, and complex ions in solution.

92. Ramart-Lucas, P., *et al.* Many papers in the French journals, including *Comptes rend., Ann. chim.,* and *Bull. soc. chim.,* especially in the period 1931–38; "Structure des Molecules et Spectres d'Absorption," in "Traite de Chimie Organique," sous le direction de V. Grignard, Secretaire General, Paul Baud, Tome II, Fasicule I (1936).

Much data and discussion of the relation of absorption spectra and chemical structure, including such specific topics as the effects of forming atoms into a ring (cyclization).

93. Smakula, A. *Angew. Chem.* **47**, 657–65 (1934).

Summarizes the work by Hausser, Kuhn, and others on the absorption by conjugated chains of atoms; the now classical example of the effect of increasing the length of the conjugated chain (in the diphenyl polyenes) is included.

94. Woodward, R. B. *J. Am. Chem. Soc.* **63**, 1123–6, 2727–9 (1941); **64**, 72–5, 76–7 (1942).

Analysis of the spectra of certain unsaturated ketones permits generalizations which show clearly both additive and chemical-constitutive effects. See also Evans, L. K., and Gillam, A. E., *J. Chem. Soc.* **1941**, 815–20.

Investigation of Methods for Determining the Filling Power of Feathers*

Norman B. Edelman†

Study of the comparative properties of filling materials for sleeping bags and cold-weather clothing were carried out by various agencies as wartime projects. The importance of expanded research in this direction now is emphasized by the reports on equipment which are being received from the current Alaskan Task Forces, indicating the need for further study in the development of better protection for troops in cold climates. It will be recognized that this paper deals with one type of possible materials, and is a contribution to the general knowledge of the subject.

Abstract

The study reported here is concerned with establishing the optimum method for determining the filling power of feathers and down mixtures both as a research tool and as an acceptance quality-control procedure.

Typical load compression curves of feathers and pressure distribution curves of a sleeper on a sleeping bag are shown.

The need for a reliable method of measuring the space-filling ability of feathers was recognized as a result of the experience gained during World War II by the Army Quartermaster Corps in its procurement of the millions of pounds of feathers required for such items as sleeping bags and pillows. Inadequate devices for evaluating feathers were hampering not only the procurement program by seriously limiting the quality control that could be exercised, but the research program as well, by rendering it most difficult to recognize the relative efficiency of various other types of filling materials which, because of the critical supply situation, were being studied as possible substitutes for the standard 40 percent down-60 percent waterfowl feather mixture.

This standard combination (hereafter referred to simply as 40/60) was found to be superior to almost all other substances considered with respect to filling power. While a few materials possess greater filling ability [1] than 40/60, their use was not deemed advisable because of their inability to meet military requirements such as laundering, matting resistance, and fluffability.

Of the various qualities possessed by feathers, the first most prominent characteristic was considered to be the space-filling ability of the feather mass, for experience with waterfowl feathers had indicated that compressibility, resilience, and warmth were related to filling power. Hence, work was undertaken at the Philadelphia Quartermaster Depot to provide a method [2] which would measure the filling power of feathers and thus provide an objective means of rating feather quality.

Experimental Procedure

Preparation of Feathers. Five different grades of feathers (identified in Table I) were treated as nearly alike as possible in washing, mixing, pounding, sampling, and testing. Washing was accomplished in a standard rotating washing machine into which the feathers, enclosed in loosely woven bags, were placed. The feathers were spun in a centrifugal extractor to remove excessive moisture, and completely dried in a heated tumbler. They were then placed on a table and layered by hand fluffing into a large bin, removed in sections, and relayered until thorough mixing (three separate relayerings) had occurred. During the operation of fluffing, foreign matter and chaff were removed from the feathers.

* Based on Textile Series Report No. 32, same title as above, issued by the Office of the Quartermaster General. Released for public information by the Office of Technical Services, U. S. Department of Commerce.

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[1] The terms "filling ability" and "filling power" are used interchangeably and refer to the space-filling characteristics of fibers or feather-like materials.

[2] Other methods are given in references [1–5].

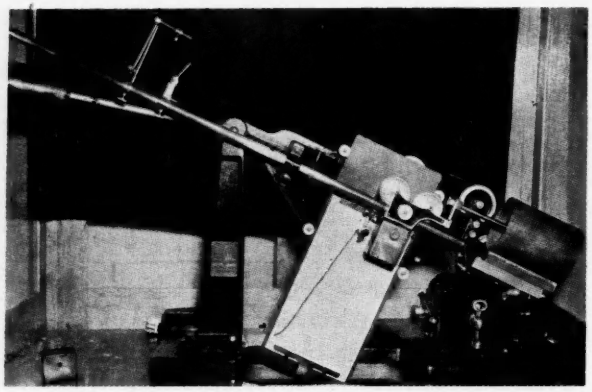

FIG. 1. *Inclined-plane serigraph shown at maximum declination of the plane at which time the piston is exerting a force of 100 grams per square inch on the feathers in the cylinder at the extreme right.*

Pounding of Feathers. A portion of the processed feathers were set aside for immediate evaluation of filling power, and the rest were subjected to a preliminary test of durability prior to measurement of filling power. Several 2-ounce samples encased in tightly woven bags were placed in the chamber of a specially constructed pounding machine [7], and pounded for 1½, 6, and 10 hours with a hammer weighing 30 pounds dropping a distance of 6 inches, fifty times a minute. Pounding was seen to twist and rotate the bags so that all bags were in direct contact with the hammer at some time.

Conditioning of Feathers. The feathers were conditioned to approximate moisture-content equilibrium at 65 percent R.H. and 70°F, sampled at random, and tested for filling power by the methods described below. Feathers tested by the box method were not conditioned, the atmosphere during testing varying from 75° to 90°F, and from 40 percent to 85 percent R.H.

Inclined-Plane Compressometer. The inclined-plane machine (Scott IP2 Model Serigraph) manufactured for the testing of textile yarns is shown in Figure 1, converted for use as a relatively [3] constant-rate-of-load compressometer. Attached to the trolley portion is a rigid rod at the end of which is a piston free to drive into a removable brass cylinder (diameter 3.85 inches, length 5.3 inches, inside dimensions) at the extreme right of the inclined plane. Also attached to the trolley is an autographic pen which records on a chart the vertical displacement of the plane (load) and the parallel displacement along the plane of the piston into the cylinder (compression).

In use, the cylinder is removed, filled with 20 grams (0.04 pound) of prefluffed feathers, weighed accurately to within 0.1 gram, and replaced in the machine. As the machine is started the plane descends and a constantly increasing pressure is placed on the feathers until a maximum of 100 grams per square inch (0.22 psi) is reached. At this point the plane has reached its maximum descent; that is, 25° of revolution from the horizontal. The plane is then automatically raised, thereby releasing the load at a constant rate. The time for completion of the

[3] Because of higher friction at the *Y* pressure (approximately 0.02 psi) when the carriage is in an almost horizontal position there is a slight deviation from constancy of load application. Another loading variable is introduced by carriage inertia. Likewise a small error is inherent in the construction of, and, hence, registration of, the load-compression recording mechanism of the machine.

TABLE I. ANALYSIS OF FIVE DIFFERENT GRADES OF WATERFOWL FEATHERS BY PERCENTAGE COMPOSITION AND CORRESPONDING SUBJECTIVE RATING

Lot ⟶	A	B	C	D	E
Physical composition					
% Down	16.6	9.7	29.69	1.5	25.5
% Fiber	3.6	10.1	8.41	22.5	0.8
% Whole feathers	36.8	15.4	59.50	3.3	42.2
% Broken feathers	39.1	56.7	0.0	59.9	29.7
% Chicken feathers	2.6	6.2	0.0	2.7	0.8
% Residue	1.3	1.9	2.40	10.1	1.0
Total %	100.0	100.0	100.0	100.0	100.0
Feather expert's rating					
Used or new	Slightly used	Used	New	Used	Slightly used
Condition of lot	Good	Fair	Excellent	Disintegrated almost to a powder	Very good
Quality	Good	Fair	Excellent	Very poor	Very good

Source: Results of tests performed at the Philadelphia Quartermaster Depot.

descent-ascent cycle of the plane is 110 seconds. Figure 2 represents an autographic chart, showing a test on one sample of feathers consisting of three typical compression-relaxation curves, together with inserted notations for measuring at pressures of 0.22 and 0.02 psi,[4] respectively, the *X* and *Y* filling power values of the feathers (to the nearest hundredth inch).

Hydrostatic Method. Figure 3 shows the apparatus used in the hydrostatic method. This consists of a 2-foot square tank over which is mounted a platform scale accurate to ± 0.03 pound, with a submersion assembly consisting of a 30-pound perforated steel frame slightly smaller than the inside of the tank, held by a rope attached to a windlass.

In use, an 18-inch square pillow is filled with 1 pound of feathers and placed in a vented waterproof vinyl bag. This is floated in the tank beneath the submersion frame with the mouth of the bag extending out of the water. As the windlass is released, the submersion frame pushes the pillow beneath the surface of the water to a mean depth of 4 inches [5] as determined by the length of the rope attached to the scale platform. After 2 minutes [6] the weight of the submerged pillow and frame is noted on the scale. From this weight is subtracted the weight of the submersion assembly when sunk to the same depth without feathers. This difference indicates the net upward push exerted by the water on the feathers. To this must be added the weight of the feathers used to obtain the total buoyant force, which can readily be converted to denote the volume of water displaced and hence the volume occupied by 1 pound of the material under test. The buoyancy value is thus identical with the specific volume [7] of the feathers.

[4] These figures represent approximations from 0.221 and 0.0185 psi for the *X* and *Y* pressures, respectively.

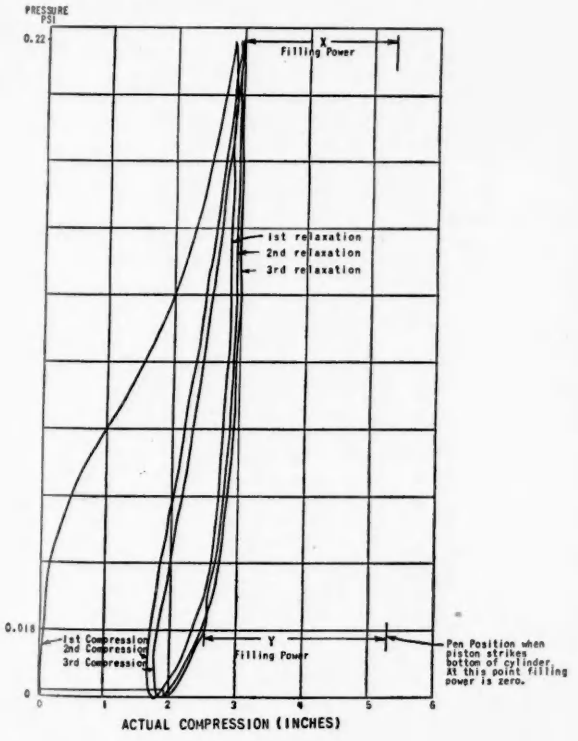

FIG. 2. *Typical load compression curves drawn by the inclined-plane apparatus when testing feathers using three cycles of operation. Source: Results of tests performed at the Philadelphia Quartermaster Depot.*

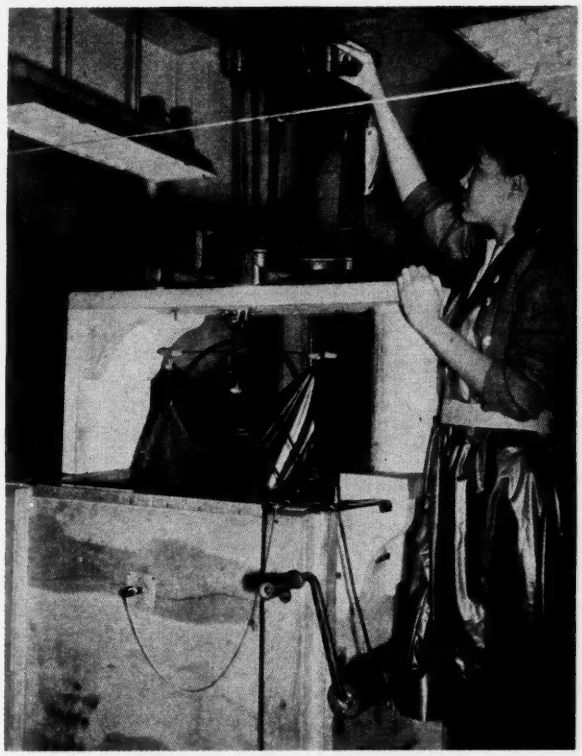

FIG. 3. *Hydrostatic machine shown in use. The submersion frame hanging from the platform scale hook has submerged the waterproof vinyl bag. This bag is shown with its top portion supported by two clamps. A venting tube reaching the enclosed pillow of feathers is shown extending out of the mouth of the bag. The vinyl bag contains 1 pound of feathers inside of a cloth pillow.*

[5] A 4-inch submersion depth corresponds to a pressure of 0.144 psi.

[6] Preliminary tests indicated that practical volume equilibrium of the compressed feathers was attained after about 1 minute.

[7] Specific volume is defined here as volume per unit weight of the material in CGS units.

TABLE II. SPECIFIC VOLUME* VALUES OF VARIOUS GRADES OF FEATHERS MEASURED BY THREE METHODS

Method	Test pressure (psi)	Specific volume (cc./g.) Lot A	Lot B	Lot C	Lot D	Lot E	Standard deviation† (cc./g.) Lot A	Lot B	Lot C	Lot D	Lot E
Box	0.0006	170	139	220	75	200	None calculated for				
Inclined plane *Y* values	0.018	20.9	18.3	24.1	13.7	21.3	0.80	0.56	0.51	0.46	0.55
Inclined plane *X* values	0.22	16.3	14.2	17.8	10.8	16.8	0.39	0.45	0.51	0.43	0.53
Hydrostatic	0.14	14.8	13.1	17.6	10.4	15.5	0.28	0.22	0.35	0.24	0.51

* Based on filling-power values (see footnote 1, page 199), as follows:

Filling power by method	×	Factor = Specific volume
Box		10.4
Inclined plane		8.57
Hydrostatic		1 (filling power obtained directly as specific volume)

† The number of samples (*N*) tested for each:

Box method	$N = 2$
Inclined-plane method	$N = 15$
Hydrostatic method	$N = 25$

Note: Results on above lots after pounding are given in footnote 1, page 199.
Source: Results of tests performed at the Philadelphia Quartermaster Depot.

Box Method. The apparatus for the box method consists of a reinforced cardboard carton measuring 24 × 24 × 27 inches. A piston is made by cutting out the center of one of the box liners to leave a 2-inch frame over which is tacked mosquito netting. Pieces of twine are attached to the frame for suspension purposes. The inside of the carton is marked off in inches on each wall starting at the bottom of the box. In use, 2 pounds of feathers accurately weighed to ± 0.01 pound are fluffed by hand and allowed to fall freely into the box. After 2 minutes the piston is gently laid on the feathers and 2 minutes later the height of the frame is noted on each of the four walls to the nearest ¼ inch. The four "height" readings thus obtained are averaged, thereby indicating the filling power of the material. The feathers are then relaxed by spreading on a table for 2 minutes before retesting.

Zero-Load Method. Attempts were made to measure the height of 2 pounds of feathers fluffed into the box without the use of the piston. Results by this "zero-load" method, however, were so indefinite that it was dropped from further consideration.

Sampling and Testing Procedure. For the inclined-plane method, five separate samples each weighing 20 grams ± 0.1 gram were chosen at random from each lot of original and pounded feathers. Each sample was given three separate tests, each of which consisted of three compression-relaxation cycles,[8] the results of each test being autographically recorded on one chart. The feathers were fluffed on a table before each test.

For the hydrostatic method, five separate 1-pound samples selected at random from each lot of original and pounded feathers were evaluated. Each sample was subjected to five separate submersion tests, after each of which the pillow of feathers was removed from the vinyl bag and thoroughly fluffed.

For the box method, two separate 2-pound samples were taken at random from each lot of original and pounded feathers and each sample was subjected to two filling-power tests. This is referred to hereafter as the "first series" of tests.

Six months later it was decided to make a further investigation of the box method, and samples were drawn from untested feathers which during that period had been stored in boxes under some pressure. Five 2-pound samples were chosen from each lot (pounded feathers had not been stored) and each sample was given fifteen successive filling-power tests, being permitted to "relax" for ½ hour prior to evaluation by being spread and fluffed on a large table. Between tests, the feathers were spread on the table for at least 2 minutes to permit relaxation.

An experienced feather expert was employed to rate the quality of the feathers and to analyze the percentage of physical components of each lot.

[8] The third cycle is known as the conditioning cycle in accordance with mechanical-conditioning concepts defined by Leaderman [6].

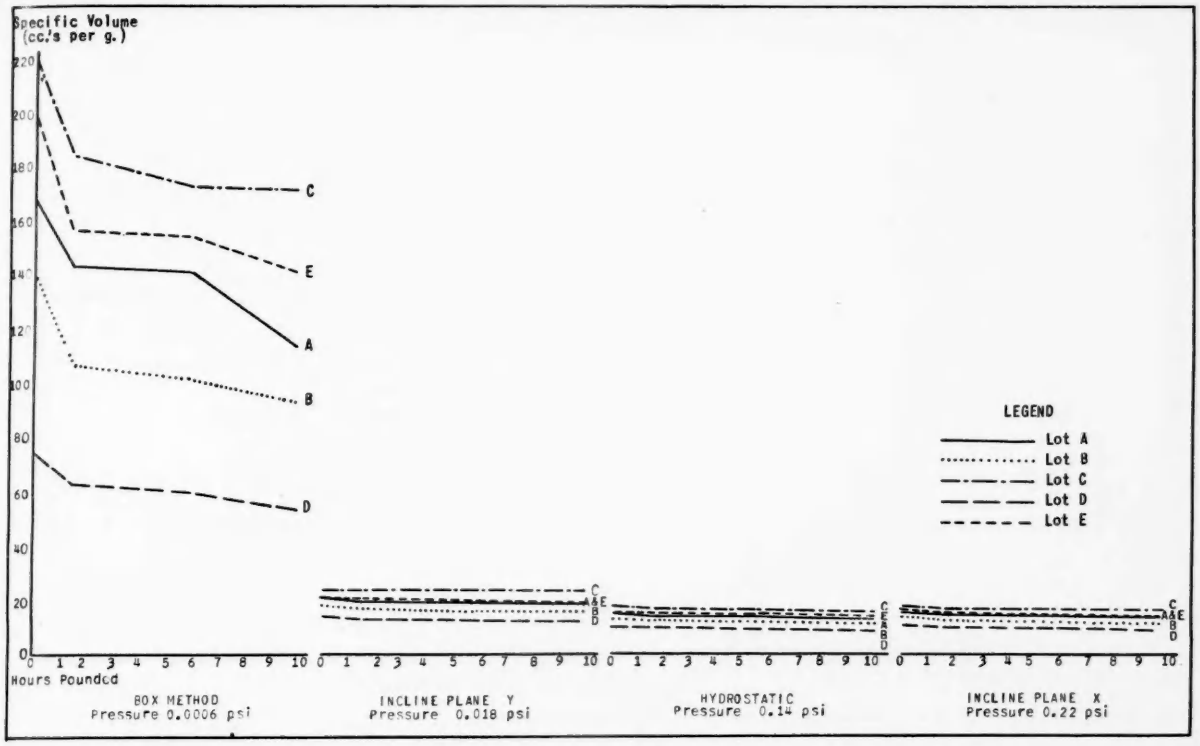

FIG. 4. *Specific volume of lots of new and used feathers before and after pounding measured by several methods at different pressures. Source: Table II.*

Discussion

Results of Filling-Power Measurements. In Table I is given the feather expert's evaluation, together with the analysis of each lot, in terms of percentage composition and grading. The filling-power results obtained by each test method were averaged and converted to figures representing specific volume and a computation was made of the standard deviation for each measurement procedure [9] on each lot and treatment as shown in Table II. In the case of the inclined-plane data the values for specific volume were obtained by multiplying the filling-power results by a factor of 8.57,[10] whereas the box-method results were converted by using a factor of 10.4.[11] As explained above, the figures obtained by the hydrostatic procedure are directly expressed in specific volume units. In Figure 4 are plotted specific volume ratings as obtained by each method on each lot and treatment of feathers. In this figure, the procedures are arranged in order of increasing pressures, the box method applying 0.0006 psi, the *Y* inclined plane 0.02 psi, the hydrostatic 0.14 psi, and the *X* inclined plane 0.22 psi.

Analysis of Data. Table III shows that the filling power of the various lots of feathers was rated in exactly the same order by the feather expert's subjective method and by the three objective procedures described above. From the filling-power (specific volume) values of Table II the chart in Figure 4 was plotted. These illustrate the greater sensitivity of the box method, indicating that differences in filling power are much more easily detected when measuring at very light loads. Conversely, increasing the pressure on feathers tends to hide the relative differences in the feathers which are shown to exist at low pressures.

Not only is the box method more effective than the other methods studied in measuring differences in filling power from lot to lot, but this procedure is also much more sensitive to changes which occur

[9] The standard deviation was not calculated on the box-method results on the first series because of insufficient data.

[10] Specific volume = cubic centimeters per gram

$$= \frac{(\text{no. of cc./cu. in.})(\text{filling power:in.})(\text{cylinder radius:in.})^2\,(\pi)}{(\text{weight of feathers:grams})}$$

$$= \frac{(16.39)(\text{filling power:in.})(1.825)^2\,(3.14)}{(20.0)}$$

$$= (8.57)(\text{filling power:in.}).$$

[11] Specific volume = cubic centimeters per gram

$$= \frac{(\text{no. of cc./cu. in.})(\text{filling power:in.})(\text{box side:in.})^2}{(\text{wt. of feathers:lbs.})(\text{no. of g./lb.})}$$

$$= \frac{(16.39)(\text{filling power:in.})(24.0)^2}{(2.00)(453.6)}$$

$$= (10.4)(\text{filling power:in.}).$$

TABLE III. RELATIVE FILLING-POWER RATINGS OF ORIGINAL FEATHERS

Subjective rating*	Test pressure (psi)	Lot C Excellent	Lot E Very good	Lot A Good	Lot B Fair	Lot D Very poor
Relative rating*						
by zero load method	None	100%	95%	71%	67%	24%
by box method	0.0006	100	90	76	62	34
by inclined plane *Y* method	0.018	100	89	87	76	57
by inclined plane *X* method	0.22	100	94	92	80	61
by hydrostatic method	0.14	100	88	84	74	59

* Objective ratings, data of Table II expressed as percent of filling power of lot C. Subjective ratings are those of Table I.
Source: Results of tests performed at the Philadelphia Quartermaster Depot.

in a given lot of feathers produced by pounding, as can be shown by plotting percent of original filling power against time of pounding.

This first series of tests focused attention on the need for further information regarding the box method's variability, which, if excessive, might easily vitiate its superior sensitivity. Hence, a second series of box-method tests was undertaken. The results plotted in Figure 5 illustrate the fact that variability of the method is relatively small and in no case affects the large differences detected in filling power from lot to lot. Analysis showed that generally a relative dispersion of about 3 percent existed around the plotted curves. The relatively high accuracy obtained by the box method is explained by the fact that a 2-pound sample is used, whereas only a 0.04-pound specimen is required by the inclined-plane method and a 1-pound sample by the hydrostatic method.

The hydrostatic method possessed three defects: (1) air tends to be trapped on the highly flexible (and crinkled) surfaces of the vinyl bag, thus producing high buoyancy values and although gentle shaking of the pillow under water removed many of these bubbles, the agitation in itself introduced pressures on the feather mass which caused unpredictable compressions; (2) it was found difficult to center the pillow under the submersion frame; hence both pillow and frame tilted, causing pressure variations; (3) the method was untidy and difficult to perform.

The value of the inclined-plane method lies primarily in the autographic stress-strain diagram obtained on mechanically conditioned samples and the control of loading rate. However, the adequacy of the sample size is open to question. In addition, the fact that approximately equal specific volumes (Table II) are obtained for the same feathers under the varying pressure conditions of the hydrostatic (0.14 psi) and inclined-plane (0.22 psi) methods suggests three possible defects in the latter method: (1) friction of the piston against the cylinder and maldistribution of pressure within the sample; (2) failure of the feathers to reach a state of bulk equilibrium; and (3) inertia effects of the piston.

To determine the pressures to which feathers lining the bottom of the sleeping bag are subjected by the sleeper, a mercury-filled thin-walled rubber bladder attached to a manometer was placed under the sleeping bag at various

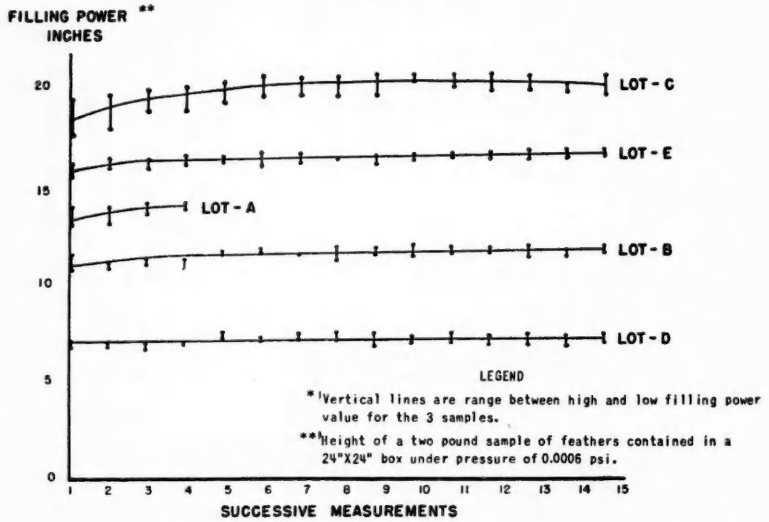
FILLING POWER **
INCHES
20
15
10
5
0
LOT - C
LOT - E
LOT - A
LOT - B
LOT - D
LEGEND
*Vertical lines are range between high and low filling power value for the 3 samples.
**Height of a two pound sample of feathers contained in a 24"X24" box under pressure of 0.0006 psi.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
SUCCESSIVE MEASUREMENTS

FIG. 5. *Filling power of various lots of feathers measured by the box method. Fifteen successive measurements were used on each of three samples* (see first legend on figure). Source: Measurements made at the Philadelphia Quartermaster Depot.*

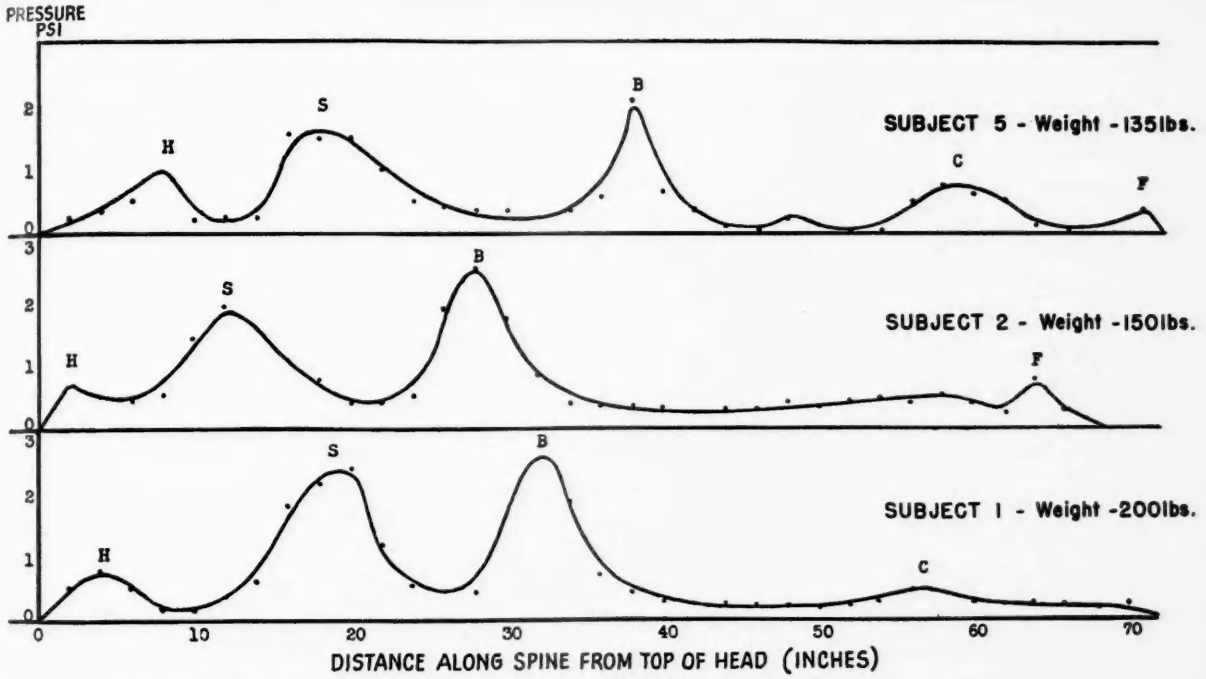

Fig. 6. *Distribution of pressure on the bottom of the sleeping bag (pressure measurements along spine of sleeper). H—Head; S—Shoulders; B—Buttocks; C—Calves; F—Feet. Source: Measurements taken at Philadelphia Quartermaster Depot.*

positions along the body of the occupant, and the height of the mercury column in the manometer was noted. Some typical results are plotted in Figure 6.

It was noted that body protuberances at the buttock and shoulder regions exerted pressures on the bottom of the sleeping bag in the order of 3 psi, but that the major area at the bottom of the bag sustained a load not exceeding 0.5 psi. The top and side of the sleeping bag, which are probably under very small pressures (near 0.001 psi), contribute in a large measure to the heat insulation afforded by the bag, and constitute by far its greatest area.

While these measurements were being made, it was noted that motion of the subject caused pressures two to three times greater than those observed when the occupant was quiet.

Conclusions

Optimum Method. The best method for determining the filling power of feathers, evaluated to date at the Philadelphia Quartermaster laboratory, is the box method—that is, one which uses a pressure of 0.0006 psi exerted on a 2-pound sample of feathers fluffed into a large container. The load should be exerted for at least 20 to 30 seconds before measurements are made, although in the tests reported a 2-minute interval was used. Reducing the load to zero increases the sensitivity of the method to small filling-power differences, but this advantage is vitiated by the greatly increased variability in results. Conversely, increasing the pressure to 0.02 psi and higher markedly reduces sensitivity by 50 percent or more with but little decrease in variability. Extrapolation of data presented to permit prediction of filling power at 3 or 4 psi indicates that differences in all feather lots tend to disappear when such higher pressures are used. Use of a controlled atmosphere is desirable, but experience shows that sufficient test accuracy in measuring the filling power of feathers is possible despite variations in temperatures from 75° to 90° and in relative humidity from 40 percent to 85 percent.

The question exists as to whether the filling power of the sleeping-bag fill should be measured at the pressures encountered in use. Although an affirmative answer might seem logical, it appears from the information already stated that filling-power differences of feathers are at a maximum at very low compressions and practically cease to be of consequence at pressures of 3 psi or more. Since all the different grades of feathers tested approached asymptotically the same minimum filling power at these higher pres-

sures, it follows that the most reliable evaluation of this quality should be obtained at the lowest test pressure consistent with accuracy, and that little is to be gained by the use of higher values of compression.

Accelerated Durability Test. The expectation that the new and best feathers would be less affected by pounding than old, presumably more dried out (brittle) feathers was satisfied only to a limited extent by measurements taken by the inclined-plane and hydrostatic methods. The results of the box method, on the other hand, were entirely at variance with expectations. Thus it may be stated that the accelerated durability test described in this report is of little use in rating feather quality.

Extrapolation of Results to Include Other Filling Materials. These conclusions are applicable to feathers and cannot be extrapolated to cover other types of materials such as kapok, cotton, wool, or synthetic fills. The durability test has already demonstrated that disintegration, excessive "balling," and other effects result from pounding certain synthetic fills of a fibrous nature. However, results of tests on these materials are as yet too meager to warrant their inclusion in this paper.

Acknowledgment

The assistance of Mr. Stanley Backer, Chief, Textile Research Laboratory Branch, Philadelphia Quartermaster Depot, under whose direction this work was performed and this report prepared; of Miss Gertrude Missuri, and Mr. Herbert Marks, who performed many of the filling-power tests; and also that of Mr. Norman E. Roberts, by whom this paper was carefully edited, are all hereby gratefully acknowledged.

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Resilience of Fibers and Fabrics*

J. H. Dillon†

THE term "resilience" enjoys frequent usage in the field of textile research and there is no question that the property or group of properties thus described is very important in textile applications. Yet, when the textile literature is perused, one discovers only a few papers in which there is any attempt to study resilience critically. In these few papers, there seem to be almost as many different definitions of "resilience" as there are authors. Hence, it appeared justifiable to make a qualitative study of this subject with the object of discovering the nature of "resilience" and the factors upon which it depends. Following is a compilation of definitions of resilience derived from a survey of the textile literature, listed according to authors, and grouped under the three categories: fibers, bulk fibers, and fabrics.

Definitions of Resilience

I. Single Fibers and Yarns

A.S.T.M.: "Resilience is ability to recover from deformation."

H. Mark [1]: If a given fiber, such as a wool, cotton, rayon, nylon, etc., is to be classified as resilient, such a bunch of irregular fibers should perform as follows:

(*a*) It must offer a moderate resistance to compression.

(*b*) It must spring back vigorously upon relaxation, even after being in compression for a considerable time.

Harold DeWitt Smith [4]: Defines five resilience indices as follows:

(*a*) "Unit yield resilience R_y"—half the product of yield stress by yield strain.

(*b*) "Unit resilience at stress p, R_p"—area under retraction curve carried to stress p.

(*c*) "Unit resilience at strain e, R_e"—area under retraction curve carried to strain e.

(*d*) "Degree of resilience at stress p, DR_p"—unit resilience at stress p/work of elongation to stress p.

(*e*) "Degree of resilience at strain e, DR_e"—unit resilience at strain e/work of elongation to strain e.

Milton Harris, L. R. Mizell, and L. Fourt [9]: Do not define resilience but discuss "elasticity" as measured inversely by area of hysteresis loop.

R. Meredith [8]: Defines "tensile elasticity" as elastic extension/total extension.

G. Halsey and H. Eyring [20]: Derive two indices of resilience in a fiber, $k_2/(k_1 + k_2)$ and μ, where k_2 = spring constant of open spring, k_1 = spring constant of closed spring in three-element model, and μ = asymmetry coefficient.

H. Wakeham and E. Honold [6]: Do not define resilience but measure "hysteresis" as the area between extension and contraction curves (cyclic test of tire cord at 2 cycles/sec.).

II. Bulk Fibers

H. Mark [1]: To be resilient, a bulk sample must offer moderate resistance to compression and spring back quickly upon release.

C. G. Winson [10]: Resilience considered to be inversely related to the area of the compression-decompression loop after the eighth cycle.

B. B. Robinson [11]: Defines three resiliencies, as follows:

(*a*) "Positive resiliency"—upward movement of fiber after release of compressive load.

(*b*) "Negative resiliency"—maximum compression of fibers below point of rest (drop test).

(*c*) "Total resiliency"—sum of positive and negative resiliencies.

III. Fabrics

H. Mark [1]: If resilient, a fabric must offer moderate resistance to deforming force, must spring

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back on unfolding, and must show only shallow wrinkles which finally disappear.

H. F. Schiefer [12]: "Compressional resilience"—amount of work recovered from specimen when pressure is decreased from 2.0 to 0.1 lbs./sq. in., expressed as a percentage of the work done on the specimen when the pressure is increased from 0.1 to 2.0 lbs./sq. in.

H. F. Schiefer [13]: "Flexural resilience"—ratio of work recovered upon unfolding to work required to fold the specimen.

K. R. Fox and F. T. I. Schwarz [5]: Do not define resilience but employ compression-decompression loop as inverse measure of resilience and interpret shape of stress-strain curves for pile fabric.

Walter J. Hamburger [7]: Defines three resiliences, as follows:

(*a*) "Difference between the areas of compression and decompression curves inversely proportional to resilience."

(*b*) Resilience varies as the percent thickness observed at maximum load.

(*c*) Resilience varies as the percent thickness observed at minimum load.

It should not be inferred that the disparity among these definitions reflects in any way upon the abilities and judgments of the authors quoted. Rather, this apparent confusion should be considered the natural result of serious attempts to define a quantity which is multi-valued according to the different sets of test conditions employed. It is obviously impractical to discuss at any length all of the papers from which the above tabulation was prepared. It should be mentioned, however, that the work of H. Mark [1] is very illuminating in discussing qualitatively the resilience of single fibers, bulk fibers, and fabrics as related to empirical evaluations such as "hand" and "drape." The treatment of molecular-structure factors as related to resilience is also of great value and interest. Mark makes no attempt to define resilience quantitatively and the omission must be considered a matter of good judgment for, in the final analysis, resilience might better be considered a field of study rather than a property. Mark does infer that resilience is a quantity which is a combination of stiffness and ability to recover from deformation. It is of interest to note that this concept is in keeping with ideas of dynamic resilience, as applied to rubber-like materials, where it is frequently defined [2] as

$$R_d = e^{-2\pi\omega b/s}, \qquad (1)$$

where ω is the natural radian frequency, b is a factor proportional to the "internal friction," and s is the "stiffness" of the material. The dynamic resilience R_d may be measured as the ratio of successive damped sinusoidal amplitudes in free vibration, from the ratio of rebound height to height of fall in an impact test, or calculated from the resonance amplitude and frequency of a forced vibration test. Incidentally, the quotient $\omega b/s$ is nearly independent of frequency of vibration [3]. Whether or not R_d is a fundamental "property" is open to question; the fact remains that it is directly related to the "elastic defect" ωb and to the stiffness s, which may correspond to the two factors suggested by Mark.

The efforts of Smith [4] to define resilience for single fibers resulted in his proposal of the five definitions listed above. In reality, however, these consist of only three basically different definitions. The first of these, R_y, is unique in the textile literature but nevertheless deserves serious consideration. However, since R_y is defined by a hypothetical early linear portion of the fiber stress-strain curve and a sharp yield point, it seems mainly of academic interest. Smith's "unit resiliences" R_p and R_e are expressed in absolute energy units (energy of retraction). His "degree of resilience," for a given stress (DR_p) or for a given strain (DR_e), is dimensionless, consisting of the ratio of energy

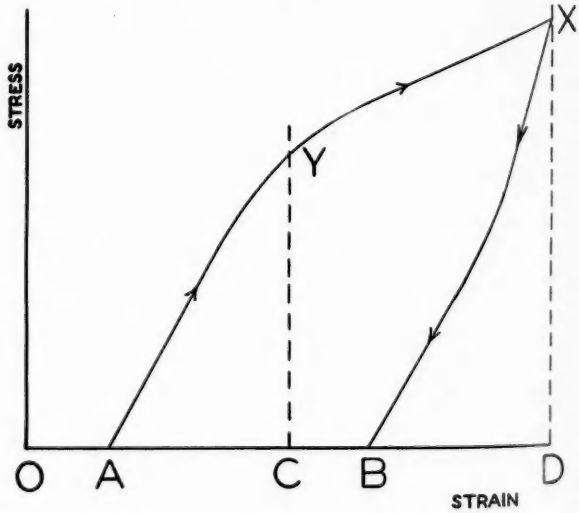

FIG. 1. *Typical stress-strain cycle.*

of retraction to energy of deformation. This quantity is quite analogous to the resilience R_d, discussed above. In examining the other papers referred to in the Literature Cited [5 to 25], we find a pronounced tendency to employ this ratio as a definition of resilience. A crude statistical analysis of the various definitions found among these particular papers yields the following distribution of definitions, as referred to the typical stress-strain loop of Figure 1.

Definition	Frequency of usage (percent)
Area AYC	$12\frac{1}{2}$
Area BXD	25
1/area AXB	$12\frac{1}{2}$
area BXD/area AXD	50

Admitting that a majority may not always be right in a scientific discussion, still this shaky analysis does indicate that there is some reason to think that a reasonable expression for resilience is

$$R' = \frac{\text{energy of retraction}}{\text{energy of deformation}}, \qquad (2)$$

bearing in mind that the deformation may be tensile, compressional, shear, or a complex combination of various types of strains. "Retraction" here is used to refer to release of strain, whether that strain be tensile, compressional, shear, or complex.

This is all very well as far as formal definitions are concerned. It must be remembered, however, that this ratio refers only to a given set of conditions for a fiber, bulk fiber sample, or fabric specimen. The value of the ratio will change when any of the following factors are varied: (1) temperature, (2) moisture content, (3) rate of strain, (4) rate of retraction, (5) number of the cycle considered (strain history), (6) rest period between cycles, (7) nature of cycle: (*a*) constant rate of strain, (*b*) constant rate of loading, (*c*) constant maximum strain, (*d*) constant maximum stress, (*e*) periodic (sinusoidal or otherwise), (*f*) impact. In light of this large number of variables, it is very clear that "resilience" is an arbitrary quantity which is defined only in form and which must be measured under the particular conditions of service of the product under consideration. Thus, it appears desirable to discuss resilience as applied to several types of products in an effort to simplify the concept by admission of its general complexity.

Resilience as Applied to Textile Products

I. Clothing

In the case of clothing, temperature is not a vital factor, both because of the thermostating effect of the human body and the inability of humans to remain alive except within a limited range of temperatures. However, moisture content is a very important factor, and due account of the type of garment and the climate for which it is intended must be taken. Rates of strain and retraction are generally rather low, and it is, in general, possible to select a standard testing speed which will represent the service rates fairly well. The number of the cycle to consider as significant is subject to argument since clothing is generally not worn continuously.

There is usually a definite rest period between cycles or between series of cycles so that secondary creep (permanent deformation) is not too important. Baggy knees and wrinkled sleeves do occur, of course, but they generally can be eliminated by proper deformation at high temperatures and moisture contents. The nature of the cycle is probably approximately that of constant rate of strain and constant maximum strain. It should be noted that "hand" and "drape" are important in clothing fabrics but they should be considered as empirical methods of estimating a composite property involving both stiffness and resilience. Hence, in the case of clothing, it appears that the role of resilience is that of a factor which controls secondary creep (or perhaps, better, delayed recovery) and the "feel" and appearance of the fabric. Heat development resulting from hysteresis or lack of resilience is never a factor.

II. Upholstery

Most of the statements made with respect to clothing apply also to upholstery except that the rate of strain in upholstery is slow and takes place under dead load, so that secondary creep is much more important. Furthermore, the cycle tends to be one of constant maximum stress with long periods of rest at zero stress.

III. Pile Fabrics

Resilience is of importance in the case of pile fabrics, particularly carpets.* Here the fibers are subjected to bending stresses and the loading curve has a point of inflection, as noted by Fox and Schwarz [5]. Temperature is generally not an important factor but moisture content varies over wide limits. A carpet is subjected to stresses of two types, impact stresses caused by walking on it, and constant stresses of long duration caused by furniture. For the former, rapid recovery is required; for the latter, complete but not necessarily rapid recovery is desirable. Fortunately, there is generally a considerable rest period between impact loadings so that negligible secondary creep takes place; of course, this is not always true for the long-duration loadings.

IV. Tire Cord

Tire cord operates under extremely severe conditions. For truck tires, the running temperatures range as high as 275°F. Since the cord as well as the rubber contributes to the generation of these undesirable temperatures, resilience is extremely important. Unfortunately, the hysteretic role of tire cord has not been generally recognized although lately some work has been done in this direction, particularly by Wakeham and Honold of the Southern Regional Laboratory of the U. S. Department of Agriculture [6]. The moisture content of cord in a tire is still a subject of debate. Special precautions are taken to build rayon tires dry but rubber is not impermeable to moisture, so the final moisture content in service is a function of running temperature, length and frequency of trips, and average climatic conditions. The rates of strain and retraction are very high, the effective frequency of stressing being considerably higher than the frequency of revolution of the wheel. Obviously, the equilibrium cycle must be considered and it must be kept in mind that superposed upon the cyclic dynamic stress is the static inflation stress which influences the strain cycle and tends to give secondary creep in the cords, or "growth" of the tires. The cycle is far from sinusoidal but no method of laboratory testing has yet been devised which employs the complex impact excitation with intervening rest periods which exists in an operating tire.

The widely differing conditions found among these few examples indicate clearly that any resilience test must be clearly specified so that it relates to the particular product under consideration. Thus, a fiber which might be considered very resilient in a clothing application—wool, for example—would not be resilient in a tire cord since it would give higher heat generation than viscose

* It has recently been argued by O. Beckwith and T. Barach that energy of compression rather than compressional resilience is important for carpets (paper read before Symposium on Resilience of Fibers and Fabrics, held at The Institute for Polymer Research, The Polytechnic Institute of Brooklyn, New York, January 25, 1947).

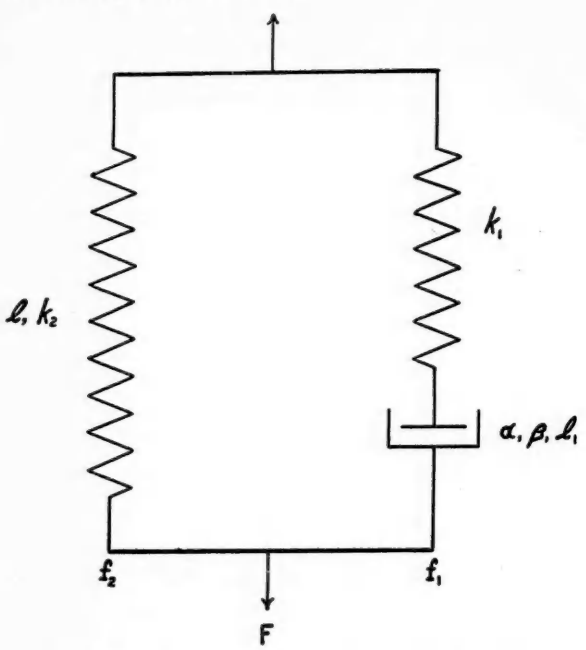

FIG. 2. *The "three-element" model of Eyring and coworkers.*

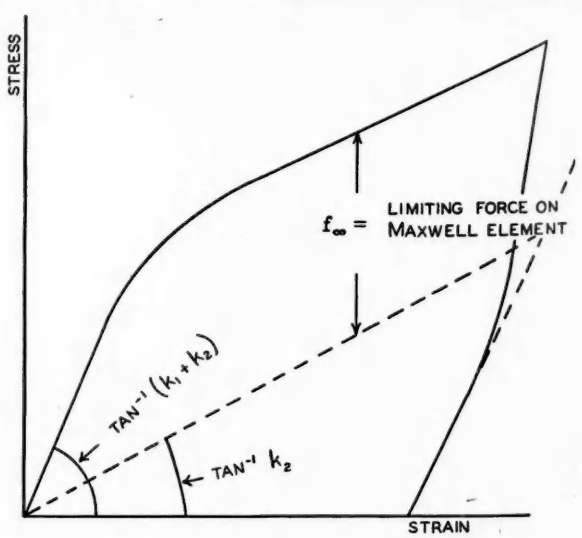

FIG. 3. *Principal features of a stress-strain cycle.*

rayon. Viscose rayon, on the other hand, would not be considered resilient as a clothing material. Mark [1] gives an excellent analysis of the molecular characteristics which are conducive to resilience in fibers, as applied in clothing and pile fabrics. In brief, he lists as desirable structure characteristics: (1) long-range regularity, (2) low intramolecular forces, (3) high degree of chain entanglement, and (4) a D.P. of 1,000 or higher. It should be emphasized that these characteristics tend to promote high extensibility as well as good recovery upon load release. A tire cord must have low static and dynamic compliances in order that the rubber and the cord will not undergo abnormally large strain cycles with concomitant high heat generation. Hence, Mark's specification for a highly resilient fiber must be amended if we choose to think of tire cord or transmission belts. So little experimental work has been done on the dynamic properties of textile materials that any attempt to characterize them with respect to dynamic resilience would be highly speculative.

Factors in Resilience

We have reached a point in this discussion where it can be concluded that resilience is a general descriptive characteristic which is desirable in most textile products and that it can be thought of as a ratio:

$$R' = \frac{\text{energy of retraction}}{\text{energy of deformation}}.$$

To use it as a quantitative index, however, we have seen that a set of test conditions must be carefully specified so that the values of resilience obtained will be pertinent to the product under consideration. The relationship between the resilience of a fiber and that of the fabric made from the fiber is not always straightforward; nevertheless, let us now direct our attention to the resilience of fibers and the factors upon which it depends.

It has been generally recognized that the creep and relaxation properties of both fibers and fabrics are related to resilience since resilience is an expression of elastic reversibility. Secondary creep, of course, is a measure of elastic irreversibility, and primary creep is a function of delayed elasticity which is also an important factor in resilience. Leaderman [25] has had some success in relating creep functions to the resilience of fibers, using the classical Maxwell concept. More recently Eyring and coworkers [14–24] have progressed somewhat further in this direction, employing the hyperbolic sine relationship:

$$\frac{dl_1}{dt} = K \sinh \alpha f = \frac{K\,(e^{\alpha f} - e^{-\alpha f})}{2}, \qquad (3)$$

which is derived from the activation rate theory of flow with the assumption of a symmetrical potential barrier. Here l_1 is the strain of a dashpot subjected to a force f_1, and α and K are constants for a given rate of deformation dl/dt of the fiber as a whole. The simplest model which they employed was the "three-element model" (see Figure 2), which consists of a Maxwell element (spring of stiffness k_1 and dashpot with "flow indices" α and β) in parallel with an open spring of stiffness k_2. The index β is defined simply as

$$\beta = \frac{dl}{dt}/K,$$

so that equation (3) becomes

$$\frac{dl_1}{dt} = \frac{1}{\beta}\frac{dl}{dt}\left(\frac{e^{\alpha f} - e^{-\alpha f}}{2}\right). \qquad (4)$$

Assigning proper values to the indices α and β, equation (4) was found to give excellent agreement

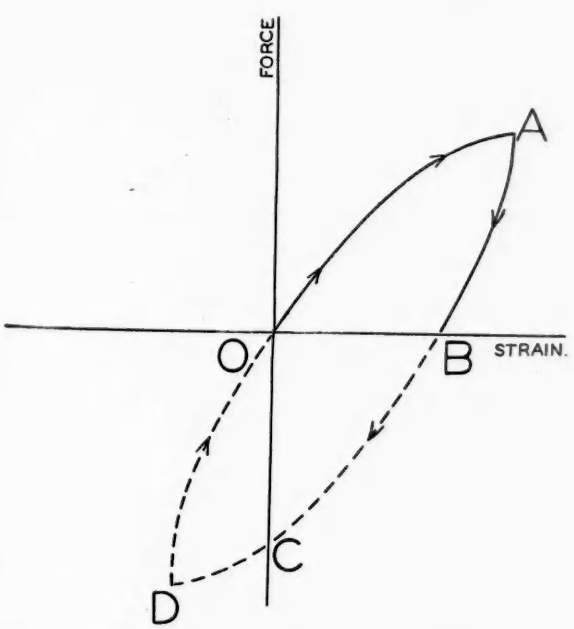

FIG. 4. *A complete stress-strain cycle (theoretical).*

between theory and experiment for the hysteresis loops obtained with several types of fibers—acetate rayon, for example. Furthermore, using the same values of α and β, it was found possible to predict accurately the creep and relaxation curves.

For some fibers, notably wool, the assumption of a symmetrical potential barrier appears too simple, and a symmetry coefficient μ must be introduced to give:

$$\frac{dl_1}{dt} = \frac{1}{\beta}\frac{dl}{dt}\left(\frac{e^{2\mu\alpha f} - e^{-2(1-\mu)\alpha f}}{2}\right), \qquad (5)$$

where a value $\mu = \frac{1}{2}$ indicates a symmetrical barrier and throws equation (5) over into the simpler form (4).

The initial slope of the extension curve (see Figure 3) is then given by the sum of the stiffnesses of the two springs of the model ($k_1 + k_2$) and the final slope by the stiffness k_2 of the open spring. Hence, a sort of resilience index is defined as

$$R'' = \frac{k_2}{k_1 + k_2}, \qquad (6)$$

which is the fraction of the resisting force which urges the stretched fiber back to its initial unstretched condition. However, as pointed out by Halsey and Eyring [20], the symmetry coefficient μ may be more satisfactory as a resilience parameter. However, here again there seems to be a question as to how general the significance of this definition may be. Possibly μ is satisfactory in defining the resilience of fibers, as applied to clothing. For example, wool would be indicated as highly resilient since it yields a value $\mu = 0.25$; that is, the barrier is highly asymmetrical in the proper direction. Acetate rayon, with a nearly symmetrical barrier, would have a value of $\mu = 0.50$ and thus would be classified as poorly resilient.

An interesting observation is made by Stein, Halsey, and Eyring [17] with respect to the stress-strain loop. They point out that a complete stress-strain cycle would not be simply the portion of the loop which is experimentally possible—that is, tensile strain—but would be a loop OABCDO, as illustrated in Figure 4. While only the section OAB of this loop is experimentally possible, consideration of the theoretical closed cycle is helpful when discussing the primary creep OB, which is obviously not a permanent set but is largely recoverable.

Conclusion

This paper has been intended only as a qualitative inquiry into the present status of knowledge of resilience. It has been found that the majority of investigators have considered resilience to be a ratio of energy of retraction to energy of deformation. It has been shown that a number of factors such as temperature, moisture content, rate of strain, rate of retraction, strain history, etc., influence the measured values of resilience. A discussion of the varying conditions which apply in different types of textile products has indicated that the conditions for testing resilience must be carefully chosen so that they simulate service conditions of the particular product under consideration. Finally, recent work on the mechanical properties of fibers has been surveyed and definitions of fiber resilience criticized. The obvious conclusion from this study is that resilience is a much abused and poorly defined term and that much remains to be learned about its significance and the factors controlling it, in single fibers, bulked fibers, and fabrics.

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1947 Chemical Research Conferences

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THE tenth summer series of special research conferences on chemistry and allied subjects, under the auspices of the American Association for the Advancement of Science, will be held this summer at Colby Junior College, New London, New Hampshire. Formerly these conferences were known as the "Gibson Island Conferences," and were held at Gibson Island in Chesapeake Bay.

Attendance at these meetings is limited; therefore applications to attend should be sent to W. George Parks, Director, Department of Chemistry, Rhode Island State College, Kingston, Rhode Island.

The sessions devoted to textiles will begin on July 7 and continue through July 11. The chairman will be Wayne A. Sisson, and the vice-chairman will be Ross Whitman. The program follows:

July 7—"The Molecular Structure of Cellulose and Its Relationship to Chemical Degradation," by Eugene Pacsu
"Some Aspects of the Chemical Reactivity of Cellulose," by Clifford B. Purves

July 8—"The Reaction of Cellulose with Formaldehyde Compounds and Its Effect on Fiber Properties," by R. F. Nickerson
"The Fine Structure, Moisture Regain, and Physical Properties of Rayon," by John A. Howsmon

July 9—"Natural Protein Fibers," by Alfred E. Brown and Milton Harris
"Synthetic Protein Fibers," by Harold P. Lundgren

July 10—"The Swelling of Cotton and Its Utilization in Water-Resistant Fabrics," by Charles F. Goldthwait
"Sorption of Acid Dyes by Nylon," by A. K. Schneider
Harold DeWitt Smith Memorial Program, lead by J. H. Dillon

July 11—"Rheological Properties of Compositions Used in the Textile Industry," by Earl K. Fischer and Charles H. Lindsley

Relationship Between Measurements of Air Permeability by Two Machines*

M. I. Landsberg † and Gerald Winston ‡

Abstract

In this paper is described the derivation of the empirical relationship between two commonly used instruments for determining air permeability—namely, the Frazier and Gurley machines. In addition, the limitations of each of the devices are discussed as well as the number of specimens necessary for testing. The correlation has also been determined by consideration of physical constants and pressure differentials, using the empirical data obtained on the Frazier and Gurley instruments operating at a pressure of 0.5 and 1.26 inches of water, respectively. The equations derived were $\log Y_F = \log 533.0 - 1.02 \log X_G$, based upon the empirical data alone, and $\log Y_F = \log 507.5 - \log X_G$ when the physical constants of the machines were considered.

THE warmth, water-resistance, and other "comfort" characteristics of a fabric are affected by its "porosity" or "air permeability"—that is, the ability of air to pass through it.

Several instruments have been devised to measure air permeability, but the two most commonly used in government test laboratories are the Gurley Densometer and the Frazier Air Permeameter [1]. Numerous Army specifications have indicated that either or both of these machines should be used to determine the porosity of wind-resistant fabrics. However, no relationship between these apparatus is known to have been established on a sound statistical basis. For this reason it is not possible to predict mathematically the values to be expected on one instrument by the information recorded on the other. Study of the instruments was therefore initiated to establish the following:

1. The relationship existing between the Gurley and Frazier instruments.**

2. The instrument which provides the most reproducible results and maximum sensitivity over a wide range of permeabilities for use in research or specification testing.

3. The least number of specimens necessary to obtain statistically sound data on each machine.

Apparatus

The Gurley machines used in this investigation (Figure 1) [2] are equipped with two coaxal circular plates, at the center of each of which is a circular orifice 0.1 or 1.0 square inch in area. These plates, positioned near the base of the apparatus, are self-aligned so that when the fabric to be tested is fastened in place securely by means of a capstan screw clamping device no air can escape along the surface of the material. The upper plate and its opening serve, respectively, as the bottom of a cylinder and as the end of a tube which extends up through the center of the cylinder. This cylinder, $9\frac{1}{2}$ inches high by $3\frac{1}{2}$ inches in diameter, is filled with oil (viscosity 60–70° Saybolt at 100°F) to a prescribed point below the upper end of the tube. Air is forced through the open top of the tube by means of an inverted cylinder $9\frac{5}{8}$ inches high by $2\frac{15}{16}$ inches in diameter (with sealed top), weighing 5 ounces, floating freely on the surface of the oil in the outer cylinder. The air pressure thus exerted is equal to 1.26 inches of water.

* Textile Series, Report No. 35, Office of The Quartermaster General, Military Planning Division, Research and Development Branch. Released for public information by the Office of Technical Services, U. S. Department of Commerce.

† Technologist, Philadelphia Quartermaster Depot.

‡ Statistician, Philadelphia Quartermaster Depot.

** It was necessary to consider three values in all computations, inasmuch as two Gurley ratings were obtained for each fabric, depending on whether the area of the orifice used was 0.1 square inch or 1.0 square inch.

The outer surface of the inverted cylinder is scored off into six sections, each of which represents 50 cc. of air. The descent of this cylinder forces air through the fabric at a rate indicated by the surface markings. Air-permeability values are obtained by noting the number of seconds required for 300 cc. of air to pass through the fabric.

As can be seen from the schematic diagram (Figure 2) the Frazier instrument consists of two chambers, a suction fan, two manometers, a calibrated orifice, and a clamp for holding the specimen. Between the two chambers is mounted one of a series of nine calibrated orifices. The air in chamber B is pumped out by means of the fan and is replaced by air coming from chamber A through the orifice. The flow of air from the atmosphere into chamber A is determined by the permeability of the specimen, 0.0412 square foot of which is exposed to testing by virtue of the size of the fabric orifice. The removal of air from chamber B creates a vacuum across a tube connecting this chamber with a vertical manometer and an oil reservoir. This gage is used to measure the pressure drop across the calibrated orifice. Still another tube connects chamber A with another reservoir and an inclined manometer. This gage, open to the air, measures the pressure drop across the fabric.

Air-permeability values are obtained by noting the vertical manometer readings while the pressure drop across the fabric is maintained at 0.5 inch of water pressure, as indicated by the inclined gage. By a consideration of the size of the calibrated orifice used, these readings can be converted into a figure which expresses the number of cubic feet of air which passes through a square foot of the fabric per minute.

Discussion of Experimental Work

Ten specimens were chosen at random from each of eighteen different fabrics (Table I) varying in air permeability from 2.0 to 432.5 cubic feet per square foot per minute as measured on the Frazier instrument, and from 1.3 to 197.3 seconds and from 0 to 25.3 seconds as determined by the Gurley 0.1-square-inch and 1.0-square-inch machines, respectively.

The same specimens were evaluated on all three machines. It was determined statistically that there was no significant difference between results obtained in this manner and those obtained by utilizing adjacent independent specimens on each instrument. Thus it was satisfactorily demonstrated that measurement of the materials on the

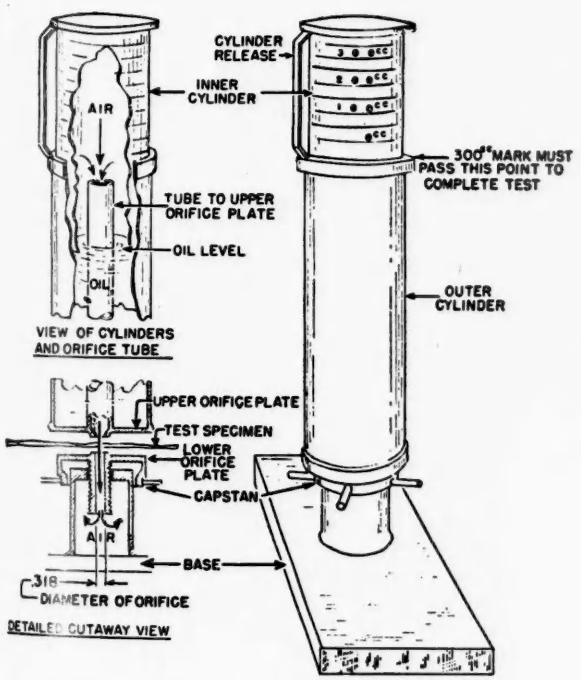

FIG. 1. *Schematic diagram of the Gurley air-permeability instrument.*

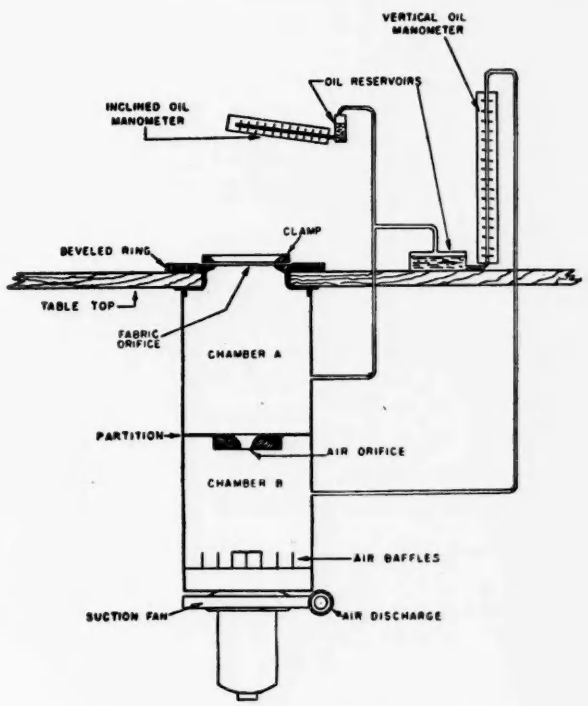

FIG. 2. *Schematic diagram of the Frazier air-permeability instrument.*

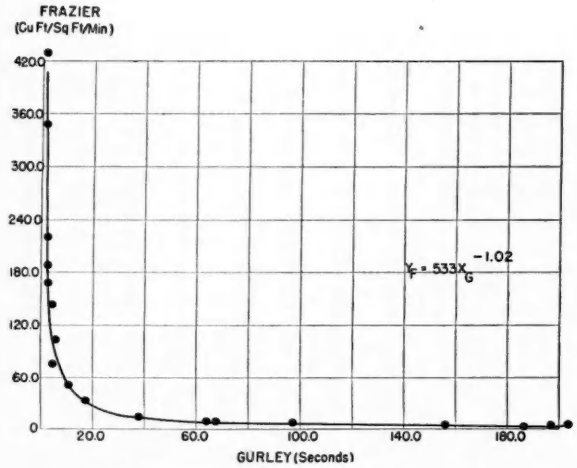

FIG. 3. *Curvilinear relationship between the Frazier and Gurley 0.1 square inch.*

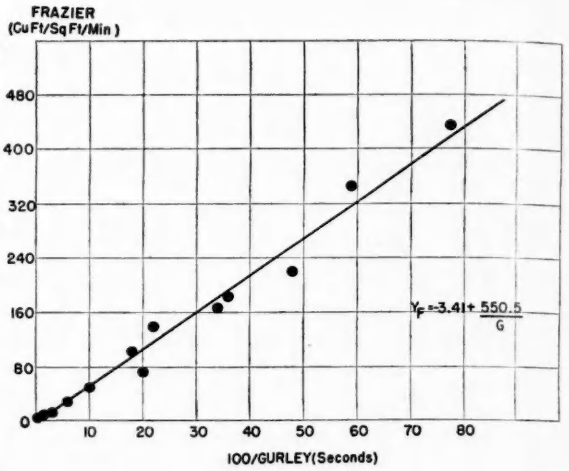

FIG. 4. *Linear relationship of measurements of air permeability by Frazier and reciprocal of Gurley 0.1 square inch.*

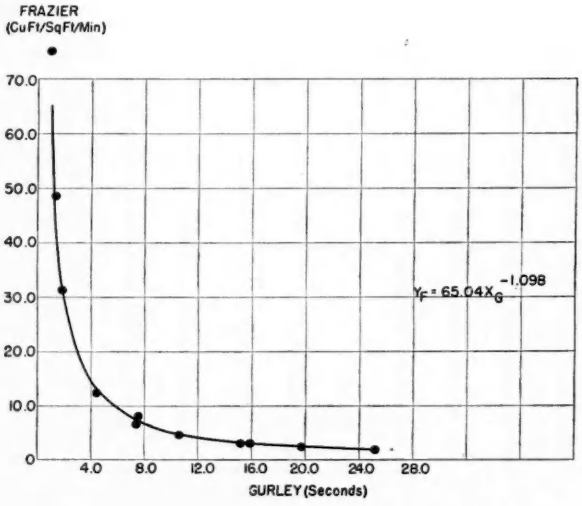

FIG. 5. *Curvilinear relationship between the Frazier and Gurley 1.0 square inch.*

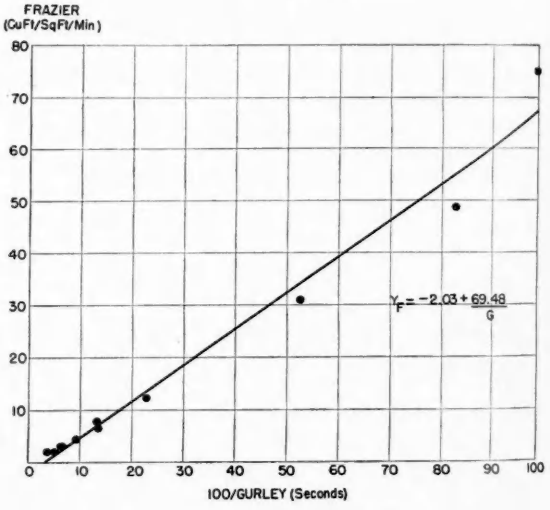

FIG. 6. *Linear relationship of measurements of air permeability by Frazier and reciprocal of Gurley 1.0 square inch.*

Frazier machine had no appreciable effect upon their porosity as indicated by subsequent Gurley measurements. Interpretations were based upon a comparison of the average values of air permeability as measured on the Frazier and Gurley apparatus.

A regressional analysis was made establishing a curvilinear relationship between measurements made on the Frazier and those made on either of the Gurley instruments. In Table I will be found (*a*) the average air-permeability values of ten specimens of the eighteen fabrics as measured on the three machines, (*b*) the regressional equations showing the mathematical relationship between the Frazier and the two Gurley apparatus, and (*c*) a Gurley-Frazier conversion table. Consideration of these figures indicates clearly the high association between Gurley and Frazier measurements.

The points plotted in Figure 3 illustrate the curvilinear relationship existing between the average of ten determinations on each of the eighteen fabrics as measured on the Frazier apparatus and the Gurley 0.1-square-inch machine. The relationship ($Y_F = 533\, X_G^{-1.02}$) based upon a minimum difference existing between the square of the log of the actual and estimated values is indicated by the solid line. In contrast, a relationship

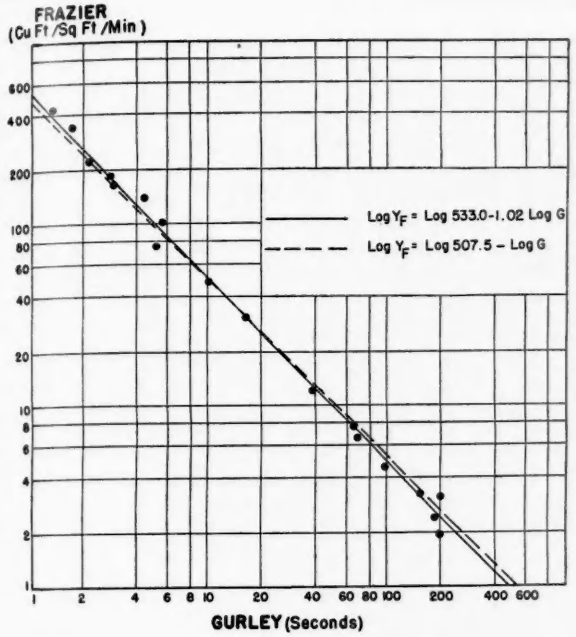

FIG. 7. *Relationship between Frazier and Gurley 0.1 square inch.*

($Y_F = 570.3\ X_G^{-1.06}$) based upon the minimum difference between the square of the actual and estimated values was computed as shown in Table I, so that Frazier readings at the extreme ranges could be determined more accurately. Figure 4 has been prepared to show the linear relationship which exists when reciprocals of values as measured by the Gurley instrument are used to estimate Frazier readings. Figures 5 and 6 correspond to Figures 3 and 4, respectively, illustrating the relationship existing between measurements on the Gurley 1.0-square-inch and the Frazier machines.

To analyze the comparative variability of the three instruments, ten specimens of each of six types of Army fabrics were used. Their air-permeability values ranged from 7.8 to 141.6 cubic feet per square foot per minute by Frazier measurements, and from 4.6 to 64.6 seconds and from 1.0 to 11.6 seconds as determined respectively by the Gurley 0.1-square-inch and Gurley 1.0-square-inch machines. Since Gurley measurements would be more widely dispersed than Frazier measurements with respect to very dense fabrics and since the opposite would be true in determining the permeability of more porous materials, samples were chosen from this middle group to avoid bias in the comparison.

Determination of the most reproducible machine and the least number of samples required to obtain statistically sound data was accomplished by computing the coefficients of variation for the Frazier, Gurley 0.1-square-inch and Gurley 1.0-square-inch instruments (Table II). These average coefficients were found to be 6.1, 8.8, and 8.5 respectively. It is indicated that the variability of air-permeability values registered on the Frazier device does not differ significantly from that given by the Gurley apparatus. With the average coefficients of variation of these representative specimens as a basis, it was determined that five in lieu of ten specimens could be used, providing a 10 percent variation is permissible from the true mean within which the means of subsequent samples may fall in 95 cases

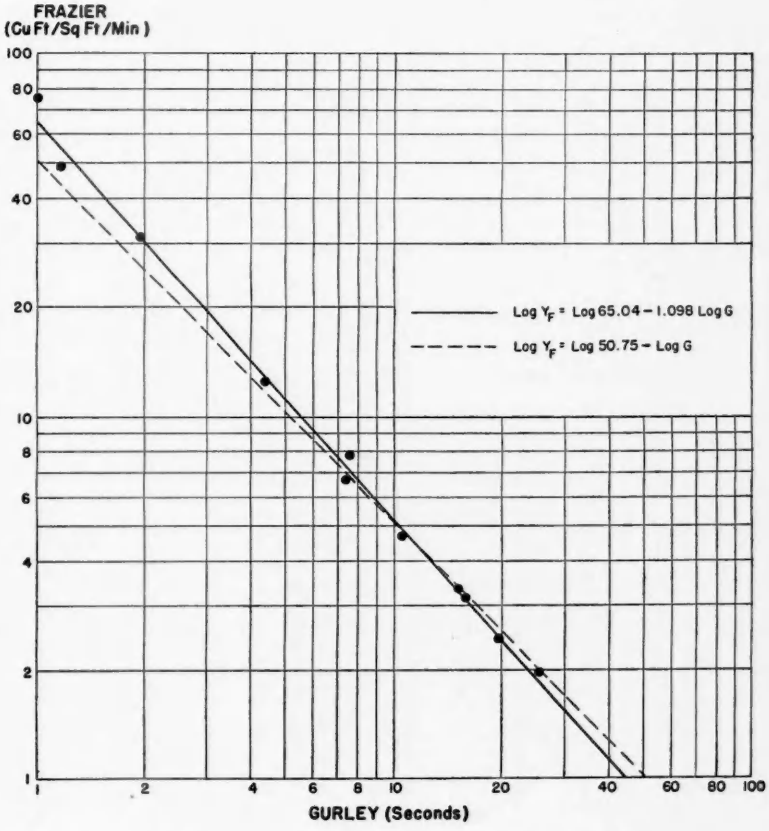

FIG. 8. *Relationship between Frazier and Gurley 1.0 square inch.*

TABLE I. REGRESSIONAL ANALYSIS OF FRAZIER AND GURLEY (0.1-SQUARE-INCH AND 1.0-SQUARE-INCH) MACHINES

Materials	Actual			Estimated Frazier values as determined by Gurley 0.1 sq. in.			Gurley 1.0 sq. in.		
	Gurley 0.1 sq. in. (sec.)	Gurley 1.0 sq. in. (sec.)	Frazier (cu. ft./ sq. ft./min.)	(1) $Y_F = -3.41 + \frac{550.5}{G}$	(2) $Y_F = 533X_G^{-1.02}$	(3) $Y_F = 570.3X_G^{-1.06}$	(4) $Y_F = -2.03 + \frac{69.48}{G}$	(5) $Y_F = 65.04X_G^{-1.098}$	(6) $Y_F = 69.95X_G^{-1.20}$
Oxford, 6.5-oz.	197.3	25.3	2.0	−0.6	2.4	2.2	0.7	1.9	1.5
Cloth, ctn., unif. twill	186.4	19.7	2.4	−0.4	2.6	2.3	1.5	2.5	2.0
Cloth, ctn., sateen									
Sateen, Zelan-treated	204.5	15.8	3.2	−0.7	2.3	2.1	2.4	3.2	2.6
Cloth, ctn., sateen	156.2	15.2	3.3	0.1	3.1	2.8	2.5	3.3	2.7
Wool bunting, blue									
Unif. twill and drill	96.9	10.6	4.7	2.3	5.0	4.6	4.5	4.9	4.1
Cloth, ctn.									
Cloth, ctn., drill	67.3	7.4	6.7	4.8	7.3	6.7	7.4	7.3	6.4
Cloth, ctn., padding canvas									
Cloth, ctn., drill	64.6	7.5	7.8	5.1	7.6	7.0	7.2	7.1	6.2
Ctn., unif. twill	38.5	4.4	12.5	10.9	12.9	12.1	13.8	12.9	11.9
Seersucker	16.3	1.9	31.2	30.3	30.9	29.9	34.5	31.4	31.5
Padding ctn., canvas	10.2	1.2	48.9	50.5	49.9	49.1	55.9	55.3	58.5
Flannel wool lining	5.1	1.0	75.1	104.5	101.2	102.1	67.5	65.0	70.0
Cloth, ctn., mohair	5.5	†	104.1	96.7	93.7	94.2			
Cloth, blanket	4.6	†	141.6	116.3	112.4	113.8			
Bunting wool, white	2.9	†	167.6	186.4	179.9	185.3			
Cloth, nylon, white	2.8	†	185.8	193.2	186.5	192.3			
Collar stiffening	2.1	†	220.4	258.7	250.1	260.6			
Bunting wool, blue	1.7	†	348.8	320.4	310.3	325.7			
Bntg., ctn., merc., dr., blue	1.3	†	432.5	420.0	407.9	432.3			

Relationship	Coefficient of correlation
(1) Linear	$r = 0.98$
(2) Curvilinear (based on log values)	$\rho = 0.99$
(3) Curvilinear (based on absolute values)	
(4) Linear	$r = 0.98$
(5) Curvilinear (based on log values)	$\rho = 0.99$
(6) Curvilinear (based on absolute values)	

† Too fast to record.

TABLE II. Comparison of Variability* of Air-Permeability Measurements on the Frazier and Gurley Machines

Fabric	Frazier $\bar{X}$ (cu. ft./sq. ft./min.)	Frazier σ	Frazier V	Gurley 0.1 sq. in. $\bar{X}$ (sec.)	Gurley 0.1 sq. in. σ	Gurley 0.1 sq. in. V	Gurley 1.0 sq. in. $\bar{X}$ (sec.)	Gurley 1.0 sq. in. σ	Gurley 1.0 sq. in. V
Cotton drill	7.8	0.64	8.3	64.6	5.70	8.8	7.5	0.78	10.3
Cotton uniform twill	12.5	0.68	5.5	38.5	3.36	8.7	4.4	0.47	10.7
Seersucker	31.2	2.14	6.9	16.3	2.11	12.9	1.9	0.21	10.8
Cotton canvas padding	48.9	4.18	8.6	10.2	1.12	11.0	11.6	0.17	1.5
Flannel wool lining	75.1	3.81	5.1	5.1	0.07	1.5	1.0	0.08	8.0
Blanket	141.6	2.97	2.1	4.6	0.46	10.1	1.1	0.105	9.6
$\bar{V}$			6.1			8.8			8.5
σV			1.36			1.97			1.90

* $\bar{X}$ = Average air permeability of ten specimens

σ = Standard deviation = $\sqrt{\dfrac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N-1}}$

V = Coefficient of variation = $\dfrac{\sigma}{\bar{X}}(100)$

$\bar{V}$ = Average coefficient of variation

σV = Standard error of coefficient of variation = $\dfrac{V}{\sqrt{2N}}\sqrt{1+2\left(\dfrac{V}{100}\right)^2}$

TABLE III. Air Flow for Various Fabrics at 0.5 and 1.26 Inches of Water Pressure

Rainard [3] (1) Frazier (cu. ft./sq. ft./min.) Measured value (0.5" water pressure)	Rainard [3] (2) Frazier (cu. ft./sq. ft./min.) Calculated value* (1.26" water pressure)	(3) Column (1) / Column (2)	Philadelphia Quartermaster Depot (4) Frazier (cu. ft./sq. ft./min.) Measured value (0.5" water pressure)	(5) Gurley (cu. ft./sq. ft./min.) Measured value† (1.26" water pressure)	(6) Column (4) / Column (5)
3.7	4.8	0.77	2.0	4.65	0.43
3.9	8.6	0.45	2.4	4.92	0.49
2.7	4.8	0.56	3.2	4.49	0.71
3.9	8.3	0.47	3.3	5.88	0.56
13.8	31.8	0.43	4.7	9.47	0.50
18.9	43.7	0.43	6.7	13.64	0.49
77.1	121.2	0.64	7.8	14.21	0.55
100.4	211.4	0.47	12.5	23.84	0.52
164.0	151.2	1.08‡	31.2	56.30	0.55
525.0	693.8	0.76	48.9	89.97	0.54
			75.1	179.94	0.42
			104.1	166.85	0.62
	Average	0.553	141.6	199.50	0.71
			167.6	316.44	0.53
			185.8	327.75	0.57
			220.4	437.00	0.50
			348.8	539.82	0.65
			432.5	705.92	0.61
				Average	0.553

* Using equation $F = K\Delta p^2 + P\Delta p$.

† Using conversion factor $\dfrac{917.7}{\text{Gurley reading}}$.

‡ Not included in average.

out of a 100. The testing of ten specimens will give results within a tolerance of 5 percent. It should be noted, however, that the experiments described in this report were performed only with fabrics which had been manufactured in accordance with Army specifications; it is possible that these

sample sizes might prove inadequate for testing other materials whose variability was less closely controlled.

In view of the excellent correlation between the empirical data listed in Table I, an attempt was made to establish a mathematical relationship between the two apparatus based upon their physical constants and the effect of their pressure differentials. To accomplish this the average permeability results obtained for the eighteen fabric samples on the Gurley machine (0.1-square-inch orifice), normally expressed as seconds/300 cc./0.1 sq. in., were converted (see column 5, Table III) to cu. ft./sq. ft./min., as follows:

$$\frac{300 \times 144 \times 60 \times 407.8}{(\text{Gurley reading})\ 28{,}317 \times 0.1 \times 406.5} \quad (1)$$

or

$$\frac{917.7}{\text{Gurley reading}} = \text{cu. ft./sq. ft./min.}, \quad (2)$$

where

300 = number of cc. of air passing through the instrument in G seconds,
28,317 = number of cubic cm. in a cubic foot,
144 = number of square inches in a square foot,
0.1 = sq. in. of cloth tested in Gurley instrument,
$\frac{407.8}{406.5}$ = correction factor to reduce volume of air passing through Gurley to standard conditions.

It was necessary to correct the air flow values thus obtained from the Gurley instrument in order to take into account the differences in pressure at which the two instruments operated. Use was made of Rainard's [3] equation relating air flow through textile fabrics at varying pressure differentials. Rainard's average air permeabilities measured (at 0.5-inch pressure differential) on the Frazier instrument for ten specimens (column 1, Table III) were used to predict air flow through fabrics at a pressure differential of 1.26 inches (column 2, Table III) by use of the equation

$$F = K\Delta p^2 + P\Delta p \text{ (Rainard's equation)} \quad (3)$$

where

F = rate of air flow (cu. ft./sq. ft./min.),
Δp = pressure differential producing this air flow,
K = slope of line relating $\frac{F}{\Delta p}$ to pressure,
P = limiting value of $\frac{F}{\Delta p}$ as Δp approaches zero.

The values of K and P (intrinsic permeability) were furnished by Rainard [3].

The ratios of air flow at the two pressure differentials (indicated in column 3, Table III) fell within a narrow range except for fabric No. 9, which was eliminated from consideration by use of Chauvenet's Criterion. Excluding this one value, the average ratio was computed to be 0.553.

A similar set of ratios was computed for the airflow measurements conducted at the Philadelphia Quartermaster Depot on both Gurley and Frazier instruments, operating at pressures of 1.26 and 0.5 inches, respectively. These are listed in column 6 of Table III. The average ratio in this case was found to be 0.553. The agreement of the average ratios of air flow at the two different pressure differentials when based upon the Rainard and the Philadelphia data warranted use of the factor 0.553 in the establishment of the conversion equation, which takes into consideration the effects of different pressures:

$$\text{Frazier reading} = \frac{917.7^* \times 0.553}{\text{Gurley reading}} = \frac{507.5}{\text{Gurley reading}} \quad (4)$$

or

$$\log(\text{Frazier reading}) = \log 507.5 - \log(\text{Gurley reading}). \quad (5)$$

Equation (5) is plotted (dotted line in Figure 7) together with the equation of the data obtained by testing the eighteen fabrics on both the Gurley and the Frazier machines (columns 1 and 3 of Table I). The similarity of the curve (solid line) based upon the actual laboratory data ($\log Y_F = \log 533.0 - 1.02 \log G$) and the curve based upon equation (5) indicated that the two equations are identical for all practical purposes. Figure 8 furnishes the same conclusion with respect to data obtained on the Gurley 1.0-square-inch machine.

Conclusions

A curvilinear relationship exists between measurements made on the Frazier machine and on either of the Gurley apparatus. Considering the physical constants of the two instruments and taking into account the effect of pressure differen-

* Table III: $\frac{\text{column 4}}{\text{column 5}} = \text{column 6}$.

tial, it is possible to predict Frazier air-permeability values from measurements made on the Gurley machine.

Although the Gurley 1.0-square-inch machine operates only in a limited range, it may be used instead of the Gurley 0.1-square-inch device to save time in measuring the porosity of low-permeability fabrics.

Because the two instruments vary in sensitivity at different levels of permeability, the Gurley machine with either 0.1- or 1.0-square-inch orifice should be used on fabrics of low porosity and the Frazier on materials of very high porosity.

Acknowledgment

This work was done and the report was prepared under the direction of Mr. Stanley Backer, Chief, Textile Research Laboratory Branch, Philadelphia Quartermaster Depot.

Acknowledgment is also made to Mr. Roger Kelly, whose calculations led to the derivation of the formula

$$F = \frac{507.5}{\text{Gurley reading}},$$

and to Mr. Norman E. Roberts, who reviewed and offered editorial comments on this paper.

Literature Cited

1. Schiefer, Herbert, and Boyland, Paul M., *J. Research Natl. Bur. Standards.* Research Paper RP 1471, May, 1942.
2. U. S. Army Specifications 100–48 (May 11, 1945).
3. Rainard, L. W., Air Permeability of Fabrics, Textile Research Journal **16**, 473 (Oct. 1946).

Discussion of Published Papers

"Cellulose Behavior with Filtered Light from a Carbon Arc Source"*

Comments by R. W. Moulton†

In this department from time to time are published discussions of papers which have appeared in previous issues of this publication. These are presented in the belief that such discussion will result in bringing out additional information with respect to a given subject. The JOURNAL *welcomes comments concerning papers which it publishes. When possible, additional data from the correspondent's research should be incorporated. The editors of course reserve the right to decide whether comments will or will not be published in this department.*

REGARDING the paper by Campbell and Fynn and the comments by Dr. E. I. Stearns,‡ we believe the following remarks will help to clarify the point under discussion and we hope they will be of interest to your readers.

Although the wave-length dial of the Beckman Quartz Spectrophotometer is calibrated as far as 2000 mμ in the infrared region, the presently used photocell does not permit significant measurements to be made beyond 1100 or 1200 mμ. The S2 type photo-sensitive surface employed has little or no sensitivity beyond this region.

The apparently significant measurements reported by Campbell and Fynn are probably due to the occurrence of a secondary spectrum which occurs in the region beyond about 1400 mμ. The mechanism of the production of this spectrum is as follows: As the wave-length dial is rotated beyond the visible toward the infrared, the visible portion of the spectrum dispersed in the plane of the slit jaws moves laterally in the plane of the slit jaws toward the prism. Eventually this portion of the spectrum strikes the prism and is again dispersed, the secondary, or redispersed spectrum following the usual light path from the prism to collimating mirror to exit slit. This secondary visible spectrum may then be measured by the photocell and give rise to data such as those reported.

Certain recently described photo-conductive cells, used with proper filters and a suitable indicating system, may be used in the 1000–2000-mμ region to make useful measurements with the Beckman Quartz Spectrophotometer. Equipment for this purpose is not yet commercially available, and for the present it is recommended that the Beckman Infrared Spectrophotometer be used for measurements at wave lengths of more than one micron.

* Title of a paper by K. S. Campbell and P. J. Fynn, which appeared in the September, 1946, issue of TEXTILE RESEARCH JOURNAL.

† National Technical Laboratories, South Pasadena, California.

‡ For this discussion of the same paper, see the January, 1947, issue, page 34.

Book Reviews

Industrialization of Latin America. Edited by Lloyd J. Hughlett. New York, McGraw-Hill Book Company, Inc., 1946. 517 pp. Price, $5.00.

(Reviewed by Fessenden S. Blanchard)

The two parts of the world likely to be of most significance to the future of American industry are Latin America and China and Japan. This book deals with the first of those areas and provides a most useful fund of information in a form valuable to American businessmen who are interested in Latin America, either for trading purposes or as a location for an industrial plant.

The author, who is managing editor of *Ingenieria Internacional Industria,* has enlisted the aid of thirty experienced businessmen, engineers, and economists in reviewing the industrial situation in Mexico, Central America, and South America. The book starts off with a particularly valuable chapter by the editor, Lloyd J. Hughlett, on "Economic Backgrounds to Industrial Development in Latin America," and it ends with a chapter on "Latin American Industrialization and Foreign Trade" by Spruille Braden, Assistant Secretary, United States Department of State. The other chapters cover seventeen different industries, thus making it easy for businessmen to concentrate on their particular fields of interest. The book covers the situation in each country by industries, as well as the Latin American situation as a whole.

The volume benefits from the advantages of a symposium in that specialists in each field have been obtained. It also suffers, although only slightly, from the disadvantage inherent in a symposium; that is, unevenness in performance. For instance, the section on the metalworking industries is particularly valuable in that it has a useful analysis of postwar demand for machine tools in Latin America. This is accompanied by a study of the prewar strengths and weaknesses in this field of each of the major countries, sources of prewar imports, and other important data.

On the other hand, the section on textiles, while extremely interesting in the historical background which it provides and in the data furnished on certain aspects of the industry, might have been even more valuable if it had included more information on the types of fabrics most needed by each country and their principal machinery requirements. We also should like to have seen a table (with some breakdown by types of fabrics) of imports, exports, and consumption.

No doubt such information is extremely difficult to obtain in some industries, and such lacks as these should not be stressed too much, in view of the splendid collection of valuable material which has been put together. All in all, we consider this to be one of the best books of its kind which we have had the pleasure of reading. It should be studied by all businessmen interested in finding within the cover of one volume a practical and usable account of the industrialization of Latin America.

Contribution to the Physics of Cellulose Fibers: A Study in Sorption Density, Refractive Power and Orientation. P. H. Hermans. Amsterdam and New York, Elsevier Publishing Co., 1946. 224 pp. Price $4.00.

(Reviewed by M. T. O'Shaughnessy)

This book is one of the series entitled "Monographs on the Progress of Research in Holland during the War," published, as the editors state, "to show the world that scientists in the Netherlands have remained active during the five years of German occupation." The author's preface states that the work described was carried out chiefly during 1943 as part of the fundamental research program of the Institute for Cellulose Research, founded in 1942 by the A.K.U. and affiliated companies. The research reported in this book is a remarkably concentrated, thorough, and closely reasoned attack, by several methods, upon the question of the molecular scale structure of the cellulose fiber. As a report of research rather than a review, the book does not discuss the work of others on the questions involved except when the latter bears directly upon the author's point of departure, methods, arguments, or conclusions.

The four major sections of the work present the results of studies in moisture sorption, density determinations in organic liquid and in water, measure-

ments of optical birefrigence, and estimates of crystallite orientation from x-ray fiber diagrams, performed on cotton, ramie, and a selection of artificial cellulose fibers both commercial and experimental. A brief but clear and clearly illustrated experimental part describes the methods used in the first three sections. This reviewer found the following results most striking: (1) the use of moisture sorption studies in proof that regenerated cellulose fibers as a class contain about half the fraction of crystalline material found in cotton and ramie; (2) the conclusion that the regenerated cellulose crystal lattice forms a hydrate, with ⅓ (or ½) H_2O per glucose unit; (3) the corroboration of conclusion (1) by density studies; (4) the conclusion, from comparison of optical and x-ray measurements, that crystallite orientation proceeds faster than over-all molecular orientation in the early stages of rayon stretching, during spinning; and (5) the conclusion, from a combination of optical and x-ray results, that the crystalline fraction of the substance of regenerated fibers is not greater than 25 percent. The interpretations (6) that moisture sorption in the amorphous parts of a fiber is essentially a solution process, with hydrate formation the first stage, as in H_2SO_4-H_2O systems, and should be interpreted without reference to internal surfaces, and (7) that densities in organic liquids are true macroscopic densities, whereas densities in water reveal the filling of molecular scale voids among the chains by the smaller water molecules, are also noteworthy. It is to be emphasized that these few citations are a selection rather than a summary.

This book should be of interest to all who are concerned with the scientific or technical aspects of textile fiber structure and properties, and will, in this reviewer's opinion, be of very great usefulness to the research man dealing directly with the fundamental aspects of these questions, particularly for rayon. As the questions treated are fundamental to any understanding of the nature of the cellulose fiber, it is inevitable that many workers in this country will find that the author's conclusions differ in one respect or another from their own beliefs. In particular, the fact that examples of the several widely different types of American rayons were, for obvious reasons, not included in his studies will leave questions as to how far his conclusions may be considered to apply to these types. Additional experimental techniques have recently been brought to bear on the question of the crystalline-amorphous ratio (by Nickerson and others), and their results will have to be included in any final estimate of the situation. In the reviewer's opinion, the value of this work as a keen analysis of the physical problem and as a model of careful experimentation and bold and self-consistent interpretation will stand, however the detailed conclusions may be modified or extended in the light of later results.

Textile Chemical Specialty Guide, 4th edition. H. R. Mauersberger, editor. New York, Textile Book Publishers, Inc., 1946. 405 pages. Price $5.00 in U.S.A. and Canada; $6.00 in other countries.

This well-known guide to purchasers of textile chemical products, the publication of which was interrupted during the war years, has appeared in expanded and revised form.

Arrangement is in three parts: Part I lists alphabetically 193 American manufacturers with their principal textile chemical products; Part II lists the products alphabetically according to their use—e.g., acids, shrink-resistant compounds, desizing agents, emulsifiers, finishing agents, etc., together with their composition and the names of the manufacturers; and Part III gives an alphabetical list of brand names and registered trademarks with the names of the manufacturers.

Because of the many changes that have occurred in the chemical supply field this up-to-date publication, which covers the market of the chemical auxiliaries used in the textile industry, is timely and should be of wide interest.

A.S.T.M. Standards on Glass and Glass Products. Philadelphia, American Society for Testing Materials, 1946. 95 pages. Price, single copies $1.25; multiple copies furnished at reduced price.

This publication is one of a series of special compilations of A.S.T.M. standards relating to specific industrial fields.

Standards and tentative standards covering glass, glass containers, glass insulators, and glass textiles are given.

ABSTRACTS

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A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications is given on page 37 of the January, 1947, issue.

ANALYSIS: TESTING: LABORATORY METHODS

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Abrasion Testing

Abraser technique simplifies wear-testing of textile goods. Arthur P. Schulze. *Textile Age* **11**, 82, 84–6 (Jan. 1947).

A description of the Taber Abraser Test, which is said to provide resistance-to-abrasion data closely paralleling the data obtained through actual service tests. The sample specimen to be tested is rotated at 60 to 70 r.p.m. and 2 abrasion wheels revolve in opposite directions through frictional contact with it and resultant abrasion lines cover a circular area of about 10 cm². A counter is actuated by the rotating specimen holder.

H. J. Burnham

Text. Research J. Apr. 1947

Adhesion Tester

Pocket-type adhesion tester for organic coatings. R. J. Phair. *Bell Labs. Record* **24**, 443–4 (Dec. 1946) (through *Bull. Inst. Paper Chem.* **17**, 218 (Jan. 1947)).

A pocket-type adhesion tester was developed by the Bell Telephone Laboratories for measuring the adhesion of a coating to its base; it is small enough to be held in the hand and adaptable to measurement of parts too large to handle in the laboratory. It measures adhesion by determining the pressure that has to be applied to a scratching tool in the instrument to make it expose the base material under the finish. The scratching element is mounted at the end of a short cylindrical rod and is pressed by a spring against the surface tested. A threaded sleeve controls the pressure exerted. In use, the tool is set for minimum pressure, which is gradually increased until the film fails. The adhesional level is then read from the scale on the upper end of the graduated rod, each division representing about a 500-gram increment. The scale covers a range of from 500–5,000 g., or from poor to excellent adhesion.

Text. Research J. Apr. 1947

Amino Acids from Modified Wool

Identification of amino acids derived from cystine in chemically modified wool. R. Consden, A. H. Gordon, and A. J. P. Martin. *Biochem. J.* **40**, 580–2 (1946) (through *Chem. Abstr.* **41**, 291*a* (Jan. 10, 1947)).

Numerous amino acids were identified in protein hydrolyzates by partition chromatography on paper. Cysteic acid was identified in oxidized wool; small amounts of lanthionine and cystic acid were found in tips of virgin wool.

Text. Research J. Apr. 1947

Cellulose Xanthate

Xanthation of cellulose-containing fibers in emulsion for determining the viscosity and average degree of polymerization of the xanthate. II. Extension of the measurements to high-viscosity celluloses and unbleached pulps. G. Jayme and J. Wellm. *Kolloid-Z.* **108**, 20–30 (1944); cf. *C.A.* **40**, 7611[5] (through *Chem. Abstr.* **41**, 281*d* (Jan. 10, 1947)).

The xanthate viscosity method, previously developed for determining the degree of polymerization (DP) of bleached pulp, was extended to include celluloses of higher solution-viscosities and unbleached pulps. Modification of the various conditions, such as concentration of the cellulose, preswelling in water, addition of abietic acid and glucose, alkali concentration, and the amounts of CS_2, showed that the DP of these cellulosic materials can be measured with sufficient accuracy

if the concentration of the xanthate solution is lowered. Instead of a xanthate concentration of 4% (which is used for bleached pulps with DP values up to 1,000), a concentration of 2% is recommended for pulps with DP of 1,000–2,000, and 1.333% for pulps with DP above 2,000; the results obtained at the lower concentrations can be multiplied by the factors 2 and 3, respectively, to give the correct results. The DP values for lignin-free celluloses obtained in this manner agreed very well with those given by the cuprammonium method. Although the lignin-containing pulps gave inhomogeneous solutions, the xanthate viscosity measurements gave good results; these were checked by similar measurements on the same pulps after careful bleaching with $NaClO_2$ and correcting for the lignin and excess hemicellulose in the unbleached pulp. The greater solubility of spruce sulfate pulp (as compared with spruce sulfite pulp) in cuprammonium solution indicates a difference in the location and concentration of the lignin in the fiber walls of these 2 pulps. This difference is not apparent in the emulsion xanthate viscosity method. The strength properties of a high DP unbleached pulp were determined, as well as those of the same pulp bleached with and without predrying of the unbleached pulp. The strength values were increased by bleaching and the undried pulp showed higher values than the dried pulp. The DP value by itself cannot be used as a measure of the strength properties which can be developed in a pulp by beating and by proper sheet formation.

Text. Research J. Apr. 1947

Chlorine Retention Test

The effect of chlorine retention on rayon fabrics. Walter Stump. *Am. Dyestuff Reptr.* **35**, 177–8 (Apr. 8, 1946).

A method of testing the effects of chlorine is described in which the fabric is treated in a solution of known chlorine content, washed, dried, and heated between metal plates at 400°F for 30 sec. Tensile-strength tests on the fabric then indicate the loss of strength caused by chlorine retention.

J. A. Woodruff

Text. Research J. Apr. 1947

Dimensional Analysis

A summary of dimensional analysis. H. L. Langhaar. *J. Franklin Inst.* **242**, 459–63 (Dec. 1946).

The fundamental theorems of dimensional analysis are derived on a purely mathematical basis, starting with the concept of dimensional homogeneity. This treatment avoids the philosophical questions which have been the cause of much controversy in the past. W. E. Davis

Text. Research J. Apr. 1947

Elasticity

Measuring elasticity of textile fibers. Frode Andersen. *Tidsskrift for Textilteknik* **4**, 152–8 (Oct. 1946).

The Schopper, Polanyi, Ballou-Silverman and Buchthal instruments for measuring fiber elasticity are compared. The Buchthal instrument permits both static and dynamic measurements. Tests with this instrument are reported for cotton and for rayon staple fiber at various atmospheric humidities, and for fibers wet with liquid water. In general the 2 types of fiber show similar elastic behavior, but the load-elongation curves for cotton are more nearly linear than those for rayon staple fiber. Elasticity appears more dependent on moisture content in the static measurements than in the dynamic measurements.

Text. Research J. Apr. 1947

Two-dimensional boundary-value problems of elasticity. B. Sen. *Proc. Roy. Soc.* **A187**, 87–101 (Oct. 8, 1946).

A new method of solving 2-dimensional problems of elasticity is developed in this paper. Airy's stress function is not used; but the stress equations of equilibrium are so transformed with the help of consistency equations that they yield simple solutions when the values of the stresses on the boundary are given. The boundaries discussed in this paper are the straight edges of a semi-infinite plate and the circular boundaries of a thin disc. Action of forces and couples in the interior of the plates are chiefly considered. Authors

Text. Research J. Apr. 1947

Electron Microscope

The magnetic electron microscope objective: contour phenomena and the attainment of high resolving power. James Hillier and E. G. Ramberg, Jr. *J. Applied Phys.* **18**, 48–71 (Jan. 1947).

When a near-focus image of a transparent specimen in the field of a magnetic electron microscope is adjusted from underfocus to overfocus, there is an apparent reversal of the Fresnel fringes which appear at the boundary of the image. This reversal takes place at exact focus. The authors have used the fringed patterns to characterize the degree of asymmetry of the objective. The origin of image asymmetries is discussed and procedures for their elimination are described. Accidental instrumental errors are listed as being due to external magnetic fields, specimen vibration, specimen stage drift, specimen drift (thermal), charging of the specimen, contamination of the specimen holder, contamination of objective lens, change of focus with change of illumination, as well as combinations of these. Mention is also made of image aberrations resulting from defects in the various electrical supplies to the microscope.

Text. Research J. Apr. 1947 T. J. Dietz

Electronics in Testing

Electronics in textile testing. E. R. Schwarz. *Am. Dyestuff Reptr.* **35**, 198–204 (Apr. 22, 1946).

A list is given of a group of textile-testing machines utilizing some of the principles of electronics. In each machine the part played by the principle involved is described. The statement is made that the use of electronics gives promise of eliminating the three bothersome factors of momentum, inertia, and

friction with which the instrument designer must contend.

J. A. Woodruff

Text. Research J. Apr. 1947

Fatigue of Materials

The statistical aspect of fatigue of materials. A. M. Freudenthal. *Proc. Roy. Soc.* **A187**, 416–29 (Dec. 13, 1946).

The phenomenon which is usually described as "fatigue" of materials, but for which the term "progressive failure" would be more adequate, is the expression, on a macroscopic scale, of the progressive destruction of the cohesive bonds as a result of the repetitive action of an external load. It has the typical features of a mass phenomenon; both the cohesive bonds and the load repetitions are collectives in a statistical sense. By applying the fundamental rules of the theory of probability, many of the experimentally established relations between the principal variables can be theoretically deduced from the purely formal assumption of the existence of a statistical distribution function of the separation-strength of cohesive bonds.

Text. Research J. Apr. 1947 Author

Fiber Tests

Textile tests in the rubber industry. I. A. Springer. *Gummi.-Ztg.* **55**, 813, 814 (1941) (through *Chem. Abstr.* **41**, 292*h* (Jan. 10, 1947)).

Natural and synthetic fibers, such as cellulose, wool, flax, nylon, polyvinyl chloride, and silk, are discussed. Procedures are given for the differentiation of a large number of fibers by optical, chemical, physical, and dye-coloring tests. Figures are presented which show the structure of a number of fibers when viewed through a microscope. The chemical tests or color tests that can be used to distinguish fibers such as wool, cotton, silk, viscose, rayon, and hemp are given in table form. Also, some chemical tests are given that can be used to determine whether cotton goods or fibers have been bleached, mercerized, or given similar treatment.

Text. Research J. Apr. 1947

Animal Hair

Distinguishing horse hair from cow-tail hair. A. Engeler and F. Wening. *Textil-Rundschau*, 136–8 (Nov. 1946).

Cow-tail hair is sometimes difficult to distinguish from horse hair. If both types of hair are soaked 30 min. in 10% NaOH at 20°C, rinsed twice with water, once with 2% boric acid, and again with water, and then rolled between 2 glass slides, horse hair will disintegrate whereas cow-tail hair will remain intact. If the hairs are dyed they should be soaked 45 min. instead of 30 min. This test is easy to do, and in the case of blends a close approximation of the percentage of each type of hair can be ascertained.

Text. Research J. Apr. 1947

Molecular Weight Determination

The determination of polymeric molecular weights by light scattering in solvent-precipitant systems. R. H. Ewart, C. P. Roe, P. Debye, and J. R. McCartney. *J. Chem. Phys.* **14**, 687–95 (Nov. 1946).

The theory of scattering by an inhomogeneous dielectric medium has been extended so that it can account for the turbidimetric behavior of polymer solutions in solvent-precipitant mixtures. It is predicted by this theory, and verified by experiment, that correct values of molecular weight are obtained by the usual interpretation of turbidity measurements if, and only if, the solvent and precipitant have the same refractive index. The practical utility of turbidimetry in high-polymer solutions is shown to be greatly increased by the proper use of solvent-precipitant mixtures. If the solvent and precipitant have different refractive indices, scattering measurements give information about the extent of selective absorption of solvent by the polymer.

Text. Research J. Apr. 1947 Authors

Resistance to Termites

The resistance of treated cotton fabrics to attack by termites and micro-organisms. R. A. St. George and Margaret S. Furry. *Am. Dyestuff Reptr.* **35**, 207–10 (Apr. 22, 1946).

A test method is described for the determination of the resistance of cotton fabric to the action of termites in natural soil. The results of this test as well as of a soil-suspension test for mildew action on 16 chemically treated cotton samples are given. Five treatments gave excellent resistance to both destructive agents. J. A. Woodruff

Text. Research J. Apr. 1947

Simple Precision Thermostat

A simple precision thermostat. Francisco Hernández Gutiérrez. *Ion* **6**, 365–6 (1946) (through *Chem. Abstr.* **41**, 320*h* (Jan. 20, 1947)).

This is used in determining solubility, density, and viscosity of recently synthetized compounds. An 800–1,200-ml. beaker containing H_2O or glycerol is fitted into a circular hole in a heavy glass plate. This plate rests on the side walls of an inverted 5-l. bottle from which the bottom is removed. This bottle serves as an air bath; heating is effected by means of a 150–200-w. light bulb. The liquid bath is agitated by bubbling air. A self-regulating contact-thermometer maintains the temperature constant to ±0.05°. Variations for temperature between 0° and 15° with (ice) water are described. Another thermostat with a 10-l. air bath was constructed with only ±0.03° temperature variation.

Text. Research J. Apr. 1947

Thermal Conductivity

The measurement of thermal conductivity of nonmetallic solids. G. L. Hall and I. B. Prettyman. *India Rubber World* **113**, 222, 235 (1945) (through *Chem. Abstr.* **41**, 306*f* (Jan. 10, 1947)).

Two simple and rapid methods for measuring the thermal diffusivity and condition of materials with low

or medium heat-transfer characteristics are described. (1) *Transient state of flow method.* This method is essentially that described by Bosomworth (*C.A.* **35**, 5347[2]). (2) *Steady-state method.* This is a modification of the flat-plate method (Barnett, *C.A.* **28**, 4269[3]); Frumkin and Dubinker (*C.A.* **30**, 6597[4]). The most important feature is the heating unit, which consists of a sheet of electric conducting rubber between 2 Cu-foil electrodes (0.001 in. thick), with the component parts located symmetrically about this central heating unit. This gives a particularly uniform temperature over the surface of the sample, with differences less than 0.5°. The apparatus has been used successfully for vulcanized sheet, sponge, resin-impregnated fabric laminates, and fuel-cell linings, typical measurements of which are tabulated.

Text. Research J. Apr. 1947

Shrinkage Control

A dye-staining technique for studying shrinkage control imparted to cotton by melamine resins. J. K. Dixon, N. T. Woodberry, and E. A. Schuman. *Am. Dyestuff Reptr.* **35**, 215–17, 236–7 (May 6, 1946).

A method of dye staining is offered as a means of approximating the residual shrinkage of the fabric after resin treatment. It is shown that the effects on the shrinkage control of variations in the length of time of cure, percentage of the applied resin, and temperature of cure are related to the reflectance values of spectrophotometric curves of fabrics dyed after the resin treatment. J. A. Woodruff

Text. Research J. Apr. 1947

Softening

Experiments with base exchange compositions. Ed. Jaag. *Textil-Rundschau*, 99–105 (Oct. 1946).

Apparatus for testing the water-softening capacity of base exchange compositions is described and illustrated. Test results are in good agreement with practical observations, and the apparatus has the advantage that all operations are carried out in glass so that the entire process is under observation. Manufacturers usually understate the water-softening capacity of their products by 20–30% as a safety factor against careless use or incomplete reaction. In the brine process of regenerating base exchange compositions, the optimum quantity of NaCl is about 3–4 times the theoretical quantity. Of all the reagents tested the natural zeolites had the lowest water-softening capacity; the synthetic resin reagents and the best of the synthetic zeolites showed the highest capacity. The active carbon type of water-softening agent is between these 2 extremes.

Text. Research J. Apr. 1947

Testing

Test methods and standardization. A. Engeler. *Textil-Rundschau*, 78–80 (Sept. 1946).

The trend in textile testing is away from dynamic tests, which destroy the sample, toward static tests, which leave the sample intact. Dynamic tests, however, are nearer to the conditions which cause failure in use. More attention is being given to the conditions existing during tests, in the interests of detecting and eliminating sources of error. Swiss textile testing and standardization are in charge of SVMT (Schweizerischer Verband für Materialprüfungen der Technik) Committee 25, St. Gallen, Switzerland.

Text. Research J. Apr. 1947

Viscosity Measurement

Viscosity measurement of solutions of rayon pulps in cuprammonium hydroxide. Alf af Ekenstam. *Svensk Papperstidn.* **50**, 1–8 (Jan. 15, 1947) (in Swedish).

The experimental part of this work embraces viscosity measurements in cuprammonium solutions according to TAPPI, using different rayon pulps. The standard method, according to TAPPI, employs only solutions containing 10 g. pulp/l. In these experiments the amount of pulp has been varied so that the viscosity has been determined for at least 2 concentrations. The specific viscosity of the pulp for infinitesimal dilution has been determined by graphic extrapolation. This value is designated (η) and is definitely to be preferred before the TAPPI viscosity. By the aid of a constant K_m it is possible to calculate the degree of polymerization over (η) since $P = (\eta)/K_m$. Gralén and Jullander in Uppsala have employed the Svedberg ultracentrifuge to show that viscosity measurements on cellulose of the type rayon pulp will give reliable average values with respect to the size of the cellulose molecule. When the viscosity measurements at different concentrations are considered the pulps investigated are remarkably similar in general character and the difference is manifested by the size of the molecule. The values obtained have been set up in a diagram showing the relation for one pulp between TAPPI viscosity and the degree of polymerization. The diagram may be used to determine the degree of polymerization for pulps of the same type as those investigated. However, more reliable values will be obtained by determinations of (η) and calculating the degree of polymerization from this value. Rayon pulp is to a very great extent polymolecular. The value obtained for the degree of polymerization, therefore, is a mean value. Different results will be obtained according to the method used for the determination. This treatise deals with the degree of polymerization by weight, P_v, and number, P_n. For rayon pulp $P_v/P_n = 2$.

Text. Research J. Apr. 1947

Viscous Flow

Stability of viscous flow between rotating cylinders. I. D. Meskyn. *Proc. Roy. Soc.* **A187**, 115–28 (Oct. 8, 1946).

Mathematical. The equations of motion are solved for the case in which the cylinders rotate in the same direction. The final expressions are simpler than those obtained heretofore, and are shown to agree with experimental data on

the angular velocity at which instability occurs. W. E. Davis
Text. Research J. Apr. 1947

Stability of viscous flow between rotating cylinders. II. Cylinders rotating in opposite directions. D. Meskyn. *Proc. Roy. Soc.* **A187**, 480–91 (Dec. 13, 1946).

The solution obtained in Part I (*Proc. Roy. Soc.* **A187**, 115–28 (Oct. 8, 1946)) is extended to the case of cylinders rotating in opposite directions, and again good agreement with experimental data on instability is obtained, while the equations are still relatively simple.
Text. Research J. Apr. 1947 W. E. Davis

Stability of viscous flow between rotating cylinders. III. Integration of a sixth-order linear equation. D. Meskyn. *Proc. Roy. Soc.* **A187**, 492–504 (Dec. 13, 1946).

This paper gives the mathematical details of the solution of the problem of oppositely rotating cylinders discussed in Part II (*Proc. Roy. Soc.* **A187**, 480–91 (Dec. 13, 1946)).
Text. Research J. Apr. 1947 W. E. Davis

Wear-Tester

An advanced fabric wear-tester. W. H. Masterson. *Am. Dyestuff Reptr.* **35**, 192, 204 (Apr. 22, 1946).

A brief discussion is given of the features of a fabric wear-tester which is described as one in which the fabrics to be tested are held on a rotating spindle. J. A. Woodruff
Text. Research J. Apr. 1947

CHEMICAL AND PHYSICAL RESEARCH

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Azo Dye Intermediate

Sodium 2-hydroxy-3-carboxynaphthalene-6-sulphonate and 2 : 6-dihydroxynaphthalene-3-carboxylic acid. E. J. Cross. *J. Soc. Dyers and Colourists* **62**, 150–1 (May 1946).

Sulfonation of 1-amino-2-hydroxynapthalene-3-carboxylic acid and elimination of the 1-amino-group from the product yields 2-hydroxy-3-carboxynaphthalene-6-sulfonic acid. The orientation of the sulfonic group was determined by conversion into the corresponding dihydroxy-naphthoic acid, the dimethyl ether of which afforded 2:6 dimethoxy-naphthalene on decarboxylation. Author
Text. Research J. Apr. 1947

Cellobiose

A constitutional synthesis of cellobiose and gentiobiose. Violet E. Gilbert, F. Smith, and M. Stacey. *J. Chem. Soc.* **1946**, 622–5 (July 1946).

The sodio derivative of 1,2,3,6-tetracetyl-β-D-glucopyranose has been condensed in the molten state with acetobromoglucose to form directly octacetyl cellobiose, smoothly converted to cellobiose. Likewise 1,2,-3,4-tetracetyl-β-D-glucose was condensed with acetobromoglucose to give octacetyl gentiobiose and thence gentiobiose. When 3-sodio diacetone glucose was heated in a sealed tube in benzene with 6-tosyl diacetone galactose there resulted a tetracetone disaccharide of the true ether type in moderate yield. The separation of acetylated hexoses and acetylated disaccharides by chromatographic methods is described.
Text. Research J. Apr. 1947 Authors

Stretching of Cellulose

The "rubber effect" in the case of cellulose hydrate. O. Kratky and A. Sekora. *Kolloid-Z.* **108**, 169–76 (1944) (through *Chem. Abstr.* **40**, 7610[8] (Nov. 20, 1946)).

The so-called "rubber effect" refers to the crystallization that takes place when rubber is stretched. K. and S. have attempted by a series of x-ray studies to determine whether or not a similar effect could be obtained with stretched cellulose hydrate (*I*). They used threads of *I*, spun without stretching and practically isotropic, with a high degree of swelling (500–600%) which could be greatly stretched even after drying (Hermans and de Leeuw, *C.A.* **32**, 1923[7]). Experiments were carried out in 3 series: (*a*) *I* threads were stretched under various loads prior to drying, and their crystallization portions were then determined quantitatively and compared with those of the unstretched threads (used as controls); (*b*) freshly spun (unstretched) isotropic threads were dried to insure varying (decreasing) degrees of swelling, and the percentage of crystallization portions was again determined and compared; (*c*) the freshly prepared threads were stretched in varying degrees and examined for crystallinity, directly after stretching (i.e., without previous drying). In all cases, the quantitative determination of crystallization areas was effected by a careful interpretation of x-ray diagrams. The methods for making such diagrams and subsequent calculations for these are described in meticulous detail. From their x-ray data (which are reproduced in photographic, graphic, and tabulated form), K. and S. conclude that within the limits of error of the methods used (i.e., ± 10%), no change in the crystalline material in *I* takes place in any of these series, and that neither stretching nor a reduction in swelling has any significant effect on the crystallinity.
Text. Research J. Apr. 1947

Swelling of Cellulose

Swelling in water and in alkalies of cellulose fibers regenerated from viscose. W. Schramek. *Monatschr. Textil-Ind.* **56**, 101–9 (1941); *Chimie & industrie* **47**, 239–40 (1942); cf. *C.A.* **36**, 4332[7]; **37**, 4243[4] (through *Chem. Abstr.* **40**, 7610[4] (Nov. 20, 1946)).

The swelling power of cellulose fibers in water and alkalies can be considered as one of the characters which govern the use of the fibers. The study of swelling presents some uncertainties and anomalies which do not permit the formulation at present of an exact theory of the mechanism of this phenomenon. S. endeavored to develop an analytical method for determining swelling while leaving the fiber perfectly free. By an ingenious device he mounted

on a slide a sort of cell in which the fiber is subjected to no pressure capable of affecting the swelling. Measurements were made of the mean length and diameter of the unswollen fibers and of fibers swollen in various media, so as to obtain the swelling both parallel and perpendicular to the fiber axis. By considering both the greatest and least diameter of a transverse section, the area of the latter was calculated by means of the equation for the ellipse, and from the difference in fiber length before and after swelling the volume of the swollen fiber was calculated. In spite of the numerous sources of error, the results led to some interesting observations; but an accurate explanation of the anomalies remains to be found. Swelling occurs differently in water and in alkalies. It is modified by outside influences and varies according to the nature, condition, and size of the fiber. It may be said that one of the chief factors is the molecular composition of the fiber; but there exist little-known structural states and molecular arrangements which might furnish the explanation of the various swelling anomalies observed.

Text. Research J. Apr. 1947

Cellulose Addition Products

Carbohydrates. XVI. The supermolecular constitution of cellulose. 4. Th. Lieser and Max Haedicke. *Kolloid-Z.* **108**, 125–31 (1944); cf. *C.A.* **37**, 2569[1] (through *Chem. Abstr.* **40**, 7603[9] (Nov. 20, 1946)).

L. and H. discuss critically the difficulties encountered by applying the methods of previous investigators in studying the composition of "addition products" formed when cellulose was treated with concentrated aqueous alkalies or acids. At first the old method (Gladstone, *J. prakt. Chem.* **56**, 247 (1852)), which entailed washing out the excess of acid (or basic) component, appeared promising. L. and H. treated cellulose with an excess of 11.6*M* H_3PO_4 for long periods and then extracted the "excess" H_3PO_4 with propyl ether. After about 14 successive extractions, the weight of the residue remained practically constant and very little acid was found in the solvent. However, control experiments showed that these results were spurious, because when 11.6*M* H_3PO_4 *alone* was extracted with propyl ether 14 successive times, the residue was still 7.2*M*, and subsequent extractions removed very little acid. In other words, a suitable solvent should be capable of removing H_2O as well as the acid from the "addition product" in the proper proportions without attacking or destroying the latter. This ideal solvent was never obtained, although about 20 neutral organic liquids (including ketones, esters, alcohol, and ethers) were tested. An application of Schreinemaker's method (*Z. physik. Chem.* **11**, 81 (1893); **55**, 73 (1906)) also gave unsatisfactory results. A critical evaluation of Vieweg's technique (*C.A.* **2**, 178) for determining the composition of cellulose-NaOH addition products, as shown by differences in alkali concentration in the centrifuged alkaline mother liquors, was also made. The errors are discussed at length. Difficulties in attempting to obtain and determine the composition of cellulose-HNO_3 and cellulose-H_3PO_4 compounds are also outlined.

Text. Research J. Apr. 1947

Cuprene

Electron-microscope examination of the microphysical properties of the polymer cuprene. John H. L. Watson and K. Kaufmann. *J. Applied Phys.* **17**, 996–1005 (Dec. 1946).

The microphysical structure of the polymer, cuprene, is examined with the aid of the electron microscope. Cuprene, prepared by the polymerization of acetylene in the presence of finely divided cuprous oxide, is shown to be a fibrous material. The electron micrographs reveal considerable structure viewed both longitudinally and transversely. The fibers appear to be hollow tubes. However, when cuprene, which is formed by the bombardment of acetylene with alpha particles, is irradiated further with the same projectiles, the resulting electron micrograph shows the formation of droplets. These appear to be spherical, having a mean diameter of 4,900 Å. in the case of an oxidized sample and 3,800 Å. for an unoxidized specimen. The droplets are usually joined to each other by short, thick necks. T. J. Dietz

Text. Research J. Apr. 1947

Deformation and Swelling

Deformation mechanism of cellulose gels. I. Present status of the problem. P. H. Hermans. *J. Polymer Sci.* **1**, 389–92 (Oct. 1946).

A review. Emphasis is placed on the relationship between deformation and swelling phenomena. Kratky's theory of "affined transformation" is discussed. E. D. Klug

Text. Research J. Apr. 1947

Deformation mechanism of cellulose gels. II. Course of crystallite orientation compared to that required by Kratky's theory. P. H. Hermans, J. J. Hermans, D. Vermaas, and A. Weidinger. *J. Polymer Sci.* **1**, 393–406 (Oct. 1946).

X-ray data obtained on isotropic model viscose filaments of various degrees of swelling showed orientations which differ from those to be expected from Kratky's explanation of the mechanism of deformation of swollen cellulose gels upon stretching. E. D. Klug

Text. Research J. Apr. 1947

Detergents

Micellar association of ionic and nonionic detergents in nonionizing solvents. Emanuel Gonick. *J. Colloid Sci.* **1**, 393–5 (Oct. 1946).

Freezing-point depression data show that the ionic detergents hexanolamine oleate and caprylate are associated in anhydrous benzene. The nonelectrolytic detergent nonaethylene glycol (mono)-laurate is not associated in benzene but is associated in cyclohexane containing

0.43% H_2O. This shows that the water blended with cyclohexane is solubilized in colloidal particles of detergent. E. D. Klug

Text. Research J. Apr. 1947

Fiber Friction

Friction between keratin surfaces as affected by some shrinkproofing treatments. M. Lipson and P. Howard. *J. & Proc. Roy. Soc. N.S. Wales* **79**, 92–100 (1946) (through *Chem. Abstr.* **40**, 7644[8] (Nov. 20, 1946)).

The object of the work was to determine the friction between treated fibers. Previously, all measurements were made on treated fibers against untreated fibers. *Apparatus for measuring friction* consisted of a machined cylinder of horn on which was placed a fiber with a hook at each end. Small weights were added to a hook to produce motion observed with a magnifying eyepiece. All measurements were made at 35° in a solution of 0.2% soap and 0.1% sodium carbonate. Coefficient of friction was calculated from formula for a sliding rope around a post, $\mu = 0.736 \log_{10} W_1/W_2$, where μ is the coefficient of friction in either direction, W_1 is the sum of the weights added, weight of hook, and weight of shellac on fiber in direction of motion, and W_2 is the weight of the hook plus shellac on the other end of the fiber. Directional frictional effect was calculated from (D.F.E.) $= (\mu_1 - \mu_2)/(\mu_1 + \mu_2)$, where μ_1 is anti-scale coefficient and μ_2 is with-scale coefficient. The 5 *unshrinkable treatments* adopted in this work were: sulfuryl chloride, alcohol caustic potash, aqueous Br, aqueous Cl, and Cl in CCl_4. Three series of measurements were made: (1) with horn treated and fibers untreated, (2) with horn untreated and fibers treated, and (3) with both horn and fibers treated. In all 3 cases, the friction was reduced with the application of the treatments, except where alcohol caustic potash was used as the treating agent. However, the greatest reduction in the coefficient of friction was observed where both surfaces were treated. In the cases where the fibers were treated and where both surfaces were treated, there was observed an increase in coefficient of friction in the case where alcohol caustic potash was used.

Text. Research J. Apr. 1947

Gelose

The effect of solvent and temperature on the viscosity of the polysaccharide of Irish moss and the effect of solvent on its initial gelation. F. A. H. Rice. *Can. J. Research* **24B**, 12–19 (Jan. 1946).

This study was an attempt to correlate the effects of temperature and inorganic salts on the viscosity and gelation behavior of aqueous solutions of gelose, the polysaccharide of Irish moss, with variations in properties of commercial preparations of the material. It was found that the viscosity follows the familiar equation $\eta_{sp}/c = [\eta] + k'[\eta]^2c$, and that both $[\eta]$ and k' decrease when inorganic salts are added to the solutions, k' being affected to a greater extent than $[\eta]$, and KCl being more effective than NaCl. KCl is also more effective than NaCl in causing gelation of the solutions. The effect of temperature on viscosity is shown only by its effect on η_{sp} at a concentration of 1 g./l., η_{sp} decreasing with increasing temperature in all cases. It was also found that the intrinsic viscosity of a sample of gelose determines the value of the lowest concentration at which a gel will form, and that the stiffness of the gel depends on the intrinsic viscosity and the concentration at which it is formed. The results are interpreted in terms of effect of salts on the solvent power of the water. W. E. Davis

Text. Research J. Apr. 1947

Glucose Anhydride

A new anhydride of D-glucose: D-glucosan <1,4>β<1,6>. R. J. Dimler, H. A. Davis, and G. E. Hilbert. *J. Am. Chem. Soc.* **68**, 1377–80 (July 1946).

A new glucosan has been isolated from the complex mixture obtained upon the vacuum pyrolysis of starch. The new anhydrohexose is dextrorotating and stable at room temperature in 0.2 *N* HCl. It contains hydroxyl groups in the *trans* position on carbons 2 and 3 which are not oxidized by periodic acid or lead tetracetate. The third hydroxyl is on carbon 5. The evidence for the structure is discussed and the properties of its triacetate, tri-*p*-toluene-sulfonate, tri-*p*-nitrobenzoate, and trimethyl ether are described. A. R. Macormac

Text. Research J. Apr. 1947

Hydrogen Bond

Theory of the hydrogen bond. A. I. Gubanov. *J. Exptl. Theoret. Phys.* (U.S.S.R.) **16**, 523–7 (1946) (through *Chem. Abstr.* **41**, 633*c* (Feb. 10, 1947)).

Some theoretical calculations, based on data of Karle and Brockway (cf. *C.A.* **38**, 2532[6]) and others, are given for the H bonds formed in the dimerization of carboxylic acids. The 8-membered ring thus formed is not planar but is puckered. The H atom between two 0 atoms is not bonded to both by resonance, but is attached to one with a normal valence bond and affects the second only by electrostatic attraction. The H atom is thus closer to one 0 atom than to the other. The high effectiveness of H in bridging two atoms is attributed to the absence of any electron structure in H; this enables the atoms in the H bridge to approach each other most closely.

Text. Research J. Apr. 1947

Molecular Weights

Molecular weight averages obtained from sedimentation velocity and diffusion measurements. Seymour Singer. *J. Polymer Sci.* **1**, 445–55 (Dec. 1946).

Molecular weight averages obtained from sedimentation velocity and diffusion measurements depend on the method of experimental observation, and the hydrodynamic character of the molecule. The more compact the molecule, the higher the average molecular weight. Generally, the average falls between the number and weight averages. Vis-

cosity molecular weights also depend on the shape of the molecule in solution but remain fairly close to the weight average. No new data. E. D. Klug

Text. Research J. Apr. 1947

Color Variation in Pigments

X-ray diffraction studies of color variation of iron oxide pigments. H. Birnbaum, H. Cohen, and S. S. Sidhu. *J. Applied Phys.* **18**, 27–9 (Jan. 1947).

X-ray diffraction data supported by observations with the electron microscope and optical microscope demonstrate that the progressive change in color of synthetic iron oxide from pale yellow to brown, when produced by a continuous process, is the result of particle growth. T. J. Dietz

Text. Research J. Apr. 1947

Flow Properties of Plastics

Theory of rolling plastics. I. Calculation of roll pressure. D. D. Eley. *J. Polymer Sci.* **1**, 529–34 (Dec. 1946).

The behavior of a plastic sheet in a rolling mill is mathematically related to the flow properties which may be measured with laboratory apparatus. No new data.

Text. Research J. Apr. 1947 E. D. Klug

Theory of rolling plastics. II. Thermal effects. D. D. Eley. *J. Polymer Sci.* **1**, 535–9 (Dec. 1946).

In the rolling of plastic sheet, the viscous work gives rise to heat. The maximum temperature reached in the interior of the plastic during shearing is calculated. It is concluded that these thermal effects may be neglected in the calculation of roll pressures. E. D. Klug

Text. Research J. Apr. 1947

Structure of Polyamides

Study of the structure of superpolyamides with x-rays. Francois Ecochard. *Compt. rend.* **222**, 656–8 (1946) (through *Chem. Abstr.* **40**, 6822[1] (Nov. 10, 1946)).

The 6 parameters of *polyhexamethyleneadipamide* (nylon) fiber calculated from the x-ray diagram by the method of Brill (*C.A.* **37**, 4576[7]) are a, b, and c, 5.00, 4.17, and 17.3 A., respectively; α, β, and γ, 81.11, 76.23, and 63.08°, respectively. Study of the x-ray diagram permits complete identification of such fibers, the *superpolyamide* of $H_2N(CH_2)_5CO_2H$ giving a different diagram.

Text. Research J. Apr. 1947

Reactivity of High Polymers

Effect of environment on the reactivity of high polymers. G. M. Burnett and H. W. Melville. *Nature* **158**, 553 (Oct. 1946).

Results of a study of an autocatalytic phenomenon in the polymerization of vinyl compounds are reported. Data are given concerning the velocity coefficients for the polymerization of vinyl acetate in ethyl acetate and n-hexane solvents; these data substantiate the belief that the autocatalytic effect is due to a decrease in the rate of chain termination. It is suggested that the reactivity of a growing polymer molecule is affected by the environment, provided that it interacts with another of its kind, but that when a monomer interacts with the polymer its high mobility facilitates penetration under all conditions and environment has no effect. Immobility or coiling up, as in a bad solvent or in the gas phase, decreases reactivity.

Text. Research J. Apr. 1947 R. W. Eyler

Rayon Spinning

The mechanics of spinning artificial fibers. II. Evolution of orientation and mechanical properties of a fiber during the process of its formation. Arnulf Sippel. *Z. Electrochem.* **50**, 256–66 (1944); cf. *C.A.* **40**, 5245[5] (through *Chem. Abstr.* **40**, 7638[9] (Nov. 20, 1946)).

In searching for a relation between the physical properties of artificial fibers and the mechanical factors in the spinning process a study has been made of the velocity variations occurring from the orifice to the point of complete solidification. Spinning of the types of fibers in which solidification is caused by solvent removal, or cooling off, produces orientation of the molecules primarily in the portions furthest away from the orifice. The determining velocity change, occurring in the layer bordering on the solidified portion, may be described by $V_E/2L(1 - 1/S)$, in which V_E = velocity at the point of complete solidification, L = distance from the orifice to the point of complete solidification, and S = ratio of stretching. For continuous stretching of swollen or dry fibers it becomes one half as large. Birefringence and tensile strength approach with increasing rate of stretch a limit which, however, is not reached because no further orientation is possible but rather because the fiber cohesion is exceeded for the specific spinning and stretching conditions. Methods are suggested leading to higher degree of orientation than the presently used methods permit and this may be obtained without a high ratio of stretch. An explanation is given for the formation of fibrils detectable by the electron microscope, the high tenacity and chemical resistance of stretch-spun acetate fibers. 16 references.

Text. Research J. Apr. 1947

Structure of Rayon

Rayon structure. Edwin L. Lovell and O. Goldschmid. *Ind. Eng. Chem.* **38**, 811–7 (Aug. 1946).

The physical properties of regenerated cellulose filaments depend not only on the chain length of the molecules but also on their arrangement with respect to one another. Two hypotheses with regard to the important influences on the different physical properties are suggested. First, the supermolecular structure is determined by the physical conditions used in regeneration. Second, the size and number of crystallites in the original cellulose play an important part in determining the structure of the regenerated filament. The effect of stretching on the structure of rayon was investigated by means of the Nickerson accessibility method (*Ind. Eng. Chem.* **34**, 1480 (1942)) and by photomicro-

graphs of etch figures prepared by the action of hydrochloric acid on the filaments. These etch figures indicate that crystalline parts are present even in completely unstretched filaments but that stretching orients the crystallites. It is suggested that rayons could be most clearly distinguished by hydrolysis for 45 min. with 2.33*N* HCl at 100°C. The accessibility method using the loss in weight as a measure of hydrolysis indicated that rayon crystallinity is determined primarily by the process of coagulation and regeneration, the effect of stretching or original cellulose crystallinity being small.

A. R. Macormac

Text. Research J. Apr. 1947

Effect of Pulp Type on Rayon

The problem of cellulose and cellulose yarn. R. E. Dörr, *et al. Jentgen's Kunstseide u. Zellwalle* **22**, 278–85 (1940); *Chimie & industrie* **47**, 239 (1942) (through *Chem. Abstr.* **40**, 7638[5] (Nov. 20, 1946)).

In the production of artificial fibers, substitution of wood cellulose for pure linters cellulose raises the problem of accessory substances which can influence operations and the properties of the finished product. These substances, which constitute the hemicellulose and which can be removed by acid hydrolysis or by solution in hot, dilute alkaline liquor, consist chiefly of pentosans and hexosans. The authors have attempted to determine to what extent the presence of these compounds affects alkalization, preaging, sulfurization, postaging, and the properties of the finished fiber. Tests carried out on celluloses of different origins (in which the polymers were determined in the form of sugars) showed that these "hemi-" compounds constitute impurities which exert an injurious effect on the properties of the fiber. It would be necessary to try to find a rapid method for eliminating these substances completely from cellulose during alkalization. Better results are obtained with sulfate than with sulfite pulp. Accurate knowledge of the raw material from the chemical, physical, and technological standpoints and of the mechanism of its purification is essential for the production of a high-grade fiber.

Text. Research J. Apr. 1947

Properties of Starches

Factors affecting some physicochemical properties of starch. R. H. Harris and Ethel Jesperson. *Food Research* **11**, 216–28 (1946) (through *Chem. Abstr.* **40**, 6857[7] (Nov. 10, 1946)).

As wheat matured, swelling power decreased irrespective of variety or environmental conditions under which the wheat was grown. Gel strength and viscosity, however, tended to increase with ripeness. These changes in starch properties were associated with marked increases in test weight per bushel and percentage of vitreous kernels, and decreases in wheat moisture content. The "amylodextrin" fraction of wheat starch was found to increase the N content and viscosity of starch solutions but to lower the pH, gel strength, and swelling power of starch. Little difference was noted among wheat, rice, and barley starches with respect to viscosity and swell. Potato starch, however, had much higher viscosity and swell than the cereal starches. Treating the starches at cooking time with 0.001 *N* electrolyte decreased the viscosity and swell of potato starch, this effect increasing with the valency of cation. $Th(NO_3)_4$ produced a greater swell than $Al_2(SO_4)_3$. In cereal starches swelling power increased with the valence of the cation, the average swell with $Th(NO_3)_4$ being more than twice that of the control.

Text. Research J. Apr. 1947

Sugars from Viscose

Study of alkaline solutions of reject viscose. W. Brissaud. *Mém. services chim. état* **30**, 133–40 (1943) (through *Chem. Abstr.* **40**, 7619[7] (Nov. 20, 1946)).

By acidification of solutions of reject viscose, 2 series of sugars are obtained: the fraction precipitating quickly is rich in pentosans (xylan), the fraction flocculating slowly is composed primarily of hexosans (mannan, hydrocellulose). Undoubtedly both fractions also contain some residues of lignin (and perhaps of pectins), which have not been studied. The solutions examined contain about 7 g./l. of the pentosan fraction. Hydrolyzing this fraction is simple; the solutions obtained, containing primarily xylose, can be used for the manufacture of proteins. The hexosan fraction should be hydrolyzed by the method used for cellulose. The solutions obtained, containing mannose and glucose, should be treated in alcohol.

Text. Research J. Apr. 1947

Cuticle of Wool

An electron-microscope investigation of the cuticle of wool. E. H. Mercer and A. L. G. Rees. *Australian J. Exptl. Biol. Med. Sci.* **24**, 147–58 (1946); cf. *C.A.* **40**, 4527[5] (through *Chem. Abstr.* **40**, 7639[6] (Nov. 20, 1946)).

The cuticular scale cell of wool contains two main components, k_1 and k_2, both probably sub-varieties of keratin, which are distinguished by their digestibilities in trypsin. The superficial component k_1 forms a smooth-surfaced layer covering the resistant component k_2 and is removed by the action of trypsin. k_1 is probably identical with the intercellular keratin, which binds the fiber, cuticle, and cortical cells together. The resistant component, not digested by trypsin, forms a honey-combed structure with characteristic pores and ridges and valleys arranged roughly linearly and parallel. Chemical reagents and enzymes attack k_1 preferentially, exposing the surface k_2 more or less clearly. Shrinkage-reduction processes in particular attack the cuticle cell initially at the k_1 component of the exposed over-lapping edge of the scales and in this way reduce the "frictional difference" of the fiber surface. Similar electron diffraction patterns are produced by k_2, films of k_1 and intercellular cement, films derived from solution of whole fiber in Na sulfide, and by isolated cortical cells.

Text. Research J. Apr. 1947

BLEACHING: DYEING: FINISHING

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Bleaching

Bleaching speeded up from days to hours. Kenneth H. Barnard. *Textile World* **96**, 104, 105, 208, 210 (Dec. 1946).

Bleach house practice in modern plants is compared with that of 25 yrs. ago. Costs have been cut tremendously while quality has been improved. H. J. Burnham

Text. Research J. Apr. 1947

Coloring Polyvinyl Chloride

The coloring of polyvinyl chloride in aqueous bath. R. Thiollet. *Rev. gén. caoutchouc* **23**, 205–6 (1946) (through *Chem. Abstr.* **40**, 6883[5] (Nov. 10, 1946)).

A review and discussion, with references to 12 patents, 10 of which are French.

Text. Research J. Apr. 1947

Color Defects

Selvage defects and off-color effects in wool and mixed fabrics. F. Stäubli. *Textil-Rundschau*, 131–6 (Nov. 1946).

Selvage defects in piece-dyed goods appear as color differences between the right or left selvage and the middle of the piece, or between the 2 selvages. There are several possible causes and the true cause is often difficult to trace. One of the chief causes is curling of the selvage. In mild cases the use of a leveling agent may lead to even dyeing. Off-color effects may also result from improper washing after fulling, or even on goods which have not been fulled. Storage of goods with some parts shielded and other parts exposed to light is another cause of color variations. Several examples in wool, cotton, and rayon are described and illustrated.

Text. Research J. Apr. 1947

Improvement of Dye Fastness

Synthetic fibers. Anon. *Dyer* **96**, 173, 175 (Aug. 16, 1946).

A brief discussion on the change in fastness properties of vat and azoic dyeings caused by after-treatment with boiling soap solutions or steaming. J. A. Woodruff

Text. Research J. Apr. 1947

Dye Migration

Migration in dyeing. Anon. *Dyer* **96**, 445–6, 459 (Nov. 8, 1946).

A review of the problem of migration in the application of direct, vat, napthol, soluble-vat, and mineral-khaki salts. J. A. Woodruff

Text. Research J. Apr. 1947

Acetate Dyeing

Synthetic fibers. Anon. *Dyer* **96**, 465, 467, 469 (Nov. 8, 1946).

A discussion is given on the use of organic solvents in dyeing processes such as the use of organic swelling agents in the dyeing of cellulose acetate. J. A. Woodruff

Text. Research J. Apr. 1947

Dyeing of Cellulose

The dichroic behavior of substantive dyes: molecular theory of the dyeing of cellulose. T. H. Morton. *J. Soc. Dyers and Colourists* **62**, 272–8 (Sept. 1946).

The observations of Ambronn on the dichroic behavior of cellulose fibers dyed with certain direct dyes have been extended. It is found that all direct dyes, all vat dyes in the leuco-form, some insoluble azo dyes, and some acid dyes on ramie exhibit positive dichroism. Elongated direct dye micelles and dye crystals exhibit negative dichroism. These dichroic phenomena are best explained by the absorption of dye by cellulose as single molecules, not as micelles. In the dyed material the elongated direct dye molecules are oriented parallel to the cellulose molecular chains with which they are coordinately combined. Direct-dye molecules are positioned transversely across elongated dye micelles. These conclusions are confirmed by the dichroic behavior of ramie dyed with alcoholic solutions of direct dyes, in which it is believed the dyes are molecularly dispersed. Normal, fully oxidized, vat-dyed materials are not appreciably dichroic. A molecular theory of the dyeing of cellulose with substantive dyes is described. The diffusion of dye molecules through the capillary pore system of cellulose is probably not a free diffusion but a thermally activated process. The essential conditions necessary for substantivity of dyes on cellulose are discussed. Author

Text. Research J. Apr. 1947

Dyeing Crepe Fabrics

Synthetic fibers. Anon. *Dyer* **96**, 365–7 (Oct. 11, 1946).

The dyeing of crepe fabrics is discussed with emphasis on the avoidance of wrinkles which are due to the failure to obtain full creping before dyeing. The use of logwood in dyeing nylon and acetate is described. J. A. Woodruff

Text. Research J. Apr. 1947

Dyeing Upholstery Fabrics

Dyeing and finishing upholstery moquettes. Anon. *Dyer* **96**, 349–50 (Oct. 11, 1946).

General information is offered on the processes of slub dyeing, pressure steaming, scouring, and piece dyeing. J. A. Woodruff

Text. Research J. Apr. 1947

Dyeing Knitted Goods

The production of fast shades on knitted cotton fabrics, nets, and lace. E. R. Wiltshire. *J. Soc. Dyers and Colourists* **62**, 313–18 (Oct. 1946).

Methods of dyeing vat and Soledon dyes on knitted cotton fabrics, nets, and lace on the winch machine are described. Means of overcoming frothing and oxidation difficulties with vat dyes are suggested, and a general method is described for dyeing a selection of the faster-to-light Soledon dyes without removal from the winch, based on washing between dyeing and developing. Author

Text. Research J. Apr. 1947

Dyeing Plastics

Dip dyeing of plastics. Louis F. Koberlein. *Interchem. Rev.* **5**, 74–7 (Autumn, 1946).

Difficulties arising from the application of techniques for dyeing synthetic textiles to the problem of dyeing plastics are being overcome by the introduction of special processes. Use of aqueous systems, sufficiently long time intervals, and high enough temperatures are advocated to avoid distortion, crocking, and crazing, the faults chiefly responsible for existing criticisms of surface-dyed plastics.

E. N. Harvey, Jr.

Text. Research J. Apr. 1947

Constitution and Dyeing Properties

Recent advances in wool dyeing. The relation of dyeing properties to dyestuff constitution. F. Townsend and G. G. Simpson. *J. Soc. Dyers and Colourists* **62**, 47–52 (Feb. 1946).

The dyeing properties of acid dyes and chrome dyes on wool are shown to be closely connected with the simpler features of the dye constitution. The practical importance of this relationship is developed in the dyeing of chlorinated, tippy, and carbonized wools, and in the dyeing of wool-cotton union materials.

Text. Research J. Apr. 1947 Authors

Use of Brine in Dyeing

Modern salt and brine usage in textile plants. Norman M. Agnew. *Am. Dyestuff Reptr.* **35**, 157–63 (Mar. 25, 1946).

A method of making a brine of rock salt and the distribution of this brine for use is diagramed and discussed. It is said that a clear brine containing 2.65 lbs. of salt per gal. is consistently obtained and its use in a dye bath offers less opportunity for error than the use of dry salt. Another advantage claimed over dry salt is that the storage and distribution of the materials are simplified.

J. A. Woodruff

Text. Research J. Apr. 1947

Mineral Khaki

The dyeing of cotton with mineral khaki. Part VIII. The incorporation of copper with chromium and iron in mineral khaki for the production of an effective fungicide and bactericide. E. Race, F. M. Rowe, and J. B. Speakman. *J. Soc. Dyers and Colourists* **62**, 9–19 (Jan. 1946).

By using chromium, iron, and copper in the impregnating bath, followed by treatment with sodium carbonate solution at room temperature, the fastness to leaching of the copper is measurably improved when compared with the leaching of copper from cotton material impregnated with copper compounds alone. Considerable data are given on methods of proofing, variations in pigments used, results of leaching tests, and the fungicidal and bactericidal efficiencies of the pigmented yarn. J. A. Woodruff

Text. Research J. Apr. 1947

The dyeing of cotton with mineral khaki. Part IX. The effect of exposure to weathering agencies on yarns pigmented with copper, chromium, and iron compounds. E. Race and F. M. Rowe. *J. Soc. Dyers and Colourists* **62**, 19–29 (Jan. 1946).

Extensive weathering tests of yarns pigmented with copper, chromium, and iron compounds are described. The results suggest that variations in atmospheric conditions of weathering can give widely differing degrees of resistance of the pigments to leaching and of photochemical degradation of the cotton fiber.

J. A. Woodruff

Text. Research J. Apr. 1947

Ultramarine Blue

A short study of ultramarine blue. Anon. *Indian Text. J.* **66**, 739–40, 746 (May 1946).

Raw materials, details of production, and cost are considered with special reference to the possibility of manufacture of ultramarine blue in India. R. K. Worner

Text. Research J. Apr. 1947

Vat Dyes

The formation of hydrogen peroxide during the oxidation of reduced vat dyes. W. Atherton and H. A. Turner. *J. Soc. Dyers and Colourists* **62**, 108–14 (Apr. 1946).

An experimental method is described for the catalytic reduction of anthraquinone and anthraquinonoid vat dyes by which the sodium salt of the reduced form is obtained free from the oxidized form and from other impurities. Evidence is given that, when the leuco-compound so obtained is reoxidized by air or by sodium hypochlorite, one peroxide group is formed for each reduced quinone group oxidized. The quantitative relation between reduced quinone groups reoxidized and peroxide groups formed appears to be independent of the tendering activity of the dye. Authors

Text. Research J. Apr. 1947

Soluble Vat Dyes

Soluble vat dyes. Anon. *Dyer* **96**, 107–10, 160–2, 180, 251–6 (Aug. 2, 16; Sept. 13; Oct. 11, 1946).

A history of the development of soluble vat dyes is followed by considerable data on the practical details of application. The properties of solubility, substantivity, sensitivity to oxidation and development, effects of temperature variation, and the salt content of the dye bath are discussed. Information is given on the one- and two-bath methods of application as well as the nitrite process, the bichromate process, and the ferric salt process of development. The treatments of fabrics on the winch and padder and the treatments of yarns in skein and package dyeing are described.

J. A. Woodruff

Text. Research J. Apr. 1947

Dyeing Properties of Vat Dyes

Some general dyeing properties of vat dyestuffs. E. Marney. *Dyer* **96**, 157–9, 205–07 (Aug. 16, 30, 1946).

A method of using laboratory dyeings to determine the rate of attainment of equilibrium between dyestuff absorbed on the fiber and dye-

stuff remaining in the liquor within practical dyeing-time limits is described. A rate-of-dyeing factor is given for 71 vat dyes. This test combined with "dip" and "strike" tests is said to give considerable aid in dye selections. The use of retarding agents to obtain level dyeing of otherwise unlevel dyeing mixtures is also discussed. A knowledge of the effects of temperature of dyeing and of the effect of varying concentration of electrolytes in the dye bath is shown to be of importance. J. A. Woodruff

Text. Research J. Apr. 1947

Crystallization of Dyes

The colour changes of vat and azoic dyes by wet and dry heat. E. Kornreich. *J. Soc. Dyers and Colourists* **62**, 318 (Oct. 1946).

The author showed previously that the change of shade of dyeings with vat and azoic dyes on soaping is due to a transition of the dye particles from the amorphous to the crystalline state. Additional evidence is now produced showing that two vat dyes deposited in the fiber simultaneously can combine on soaping to form a crystalline system different from that of the respective individual dyes. Author

Text. Research J. Apr. 1947

Classification of Direct Dyes

Report of the committee appointed by council (of the Society of Dyers and Colourists) to discuss the dyeing properties of direct cotton dyes. *J. Soc. Dyers and Colourists* **62**, 280–5 (Sept. 1946).

To establish a common basis for experimental work and to record results in operations involving the dyeing properties of direct dyes, a committee composed of dyemakers, dye users, and research workers has studied the problem and presented a number of recommendations. Migration or leveling power, salt controllability, influence of temperature on exhaustion, and influence of liquor-goods ratio on exhaustion are the properties and factors deemed adequate to define, for most purposes, the dyeing behavior of direct dyes on cotton. It is recommended that direct dyes be classified as Class A—dyes which are self-leveling; Class B—dyes which are not self-leveling but which can be controlled by regulated additions of salt; and Class C—dyes which are not self-leveling and cannot be controlled by salt alone but require additional control by temperature. Classification may be made by means of 2 tests: (1) the leveling test, performed by treating both a previously dyed and an undyed skein of bleached cotton yarn together in a boiling bath containing salt for 30 min., then comparing the results with those obtained using standard dyes of known leveling power (this test will select dyes belonging to Class A); (2) the salt controllability test, which consists essentially in determining whether a dye when dyed with $0.8 \pm 0.2\%$ of salt can give half the exhaustion obtained when dyeing with 20% salt (this test places a dye (not in Class A) in either Class B or C). The influence of temperature and of liquor-goods ratio on dyeing behavior is described. A list of 38 classified dyes is appended.

K. S. Campbell

Text. Research J. Apr. 1947

Dyes on Oriented Rayon

Matching the depth of shade of dyeings on highly oriented rayons. F. Fothergill. *J. Soc. Dyers and Colourists* **62**, 319 (Oct. 1946).

This is an appendix to a previous paper (*J. Soc. Dyers and Colourists* **60**, 93, 1944). It is found that the amount of dye prescribed by the nomogram referred to in the above article may produce in a stretch-spun (highly oriented) yarn a depth of color much too light to match the color of the normal yarn. This is due to the fact that when all the dye molecules are lying very nearly in the same direction along the length of the filament because they are attached to highly oriented cellulose molecules, they are able to absorb almost no energy from the component vibrations (light) at right angles to the length of filaments and consequently much of the light suffers no loss of selected frequencies in passing through the yarn and emerges uncolored. Most direct dyes behave in this way; most vat, sulfur, and azoic dyes behave as on normally oriented yarns. The nomogram is of value in the case of direct dyes on stretch-spun yarns in that it indicates the concentration of dye which the matching concentration must certainly exceed.

K. S. Campbell

Text. Research J. Apr. 1947

Spun-Dyed Rayon Staple

Some aspects of the dyeing and finishing of Fibro, with special reference to spun-dyed Fibro. H. Thomas. *J. Soc. Dyers and Colourists* **62**, 309–13 (Oct. 1946).

Spun-dyed rayon staple in 1.5 denier/$1\frac{7}{16}$-in., and 4.5 denier/4-in., is now available in 9 shades, and spun-dyed black in 3 types; considerable extension of these styles is planned. Because of inventory and other problems, spun-dyed staple cannot supplant the function of the rayon dyer. On the contrary, it is expected that availability of spun-dyed staple will increase the dyer's business because of the enormous possibilities of blending normally dyed shades with the comparatively few spun-dyed types, and also by increasing the demand for fast shades on staple. In certain instances, spun-dyed yarn is better and cheaper than the normally dyed variety; e.g., a spun-dyed black costs about $\frac{1}{9}$ as much as a vat-dyed black. It will not be possible to obtain all desired shades simply by blending spun-dyed staple because the necessary true minus-primary shade pigments have not been discovered; speckled rather than solid shades would be obtained in any case. The importance of shrinkage control in the finishing of spun rayon fabrics is discussed; satisfactory shape stability after several washes can be obtained without applying a crease-resistant finish. Each fabric must be treated individually, however, and in accordance with results of laboratory relaxation tests. The necessity of care in drying, to preserve the fabric's intrinsic soft handle, is stressed. Tests for urea-formalde-

hyde resin distribution using Naphthol AS-Fast Red 3GL Salt, and Duranol Violet 2R are described.

K. S. Campbell

Text. Research J. Apr. 1947

Rayon Staple: Dyeing Behavior

Rayon staple: Fiber swelling as related to dyeing behavior. Stephan Jost. *Textil-Rundschau*, 67–75 (Sept. 1946).

Chemically degraded rayon staple shows fundamental differences in dyeing behavior, governed by the conditions of degradation. Oxidative alkaline degradation sharply decreases dye uptake at equilibrium, but rate of dyeing remains unchanged. Acid hydrolysis does not affect either of these properties; swelling is less influential than in oxidative degradation. In fibers at the same degree of degradation the rate of dyeing is related to swelling capacity, but dye uptake at equilibrium is not influenced. Tests are reported with ordinary and hollow-fiber rayons. 30 references.

Text. Research J. Apr. 1947

Application of Pigments

Applying pigment colors to textiles. Winn W. Chase. *Interchem. Rev.* 5, 47–53 (Summer, 1946).

The 4 systems for applying pigment colors to textiles (aqueous-dispersion, solvent-dispersion, water-in-oil emulsion, and oil-in-water emulsion) are discussed and processes used in their application are described. Advantages and shortcomings of the different methods are pointed out. Applications of the water-in-oil emulsion system alone and in conjunction with dyes are emphasized. The future of pigment colors for textiles is bright, with the following as expected trends: a more complete range of pigment colors exhibiting the desirable qualities of the phthalocyanines, reduced crocking with dark shades, and more extensive use of 2 or more systems jointly for optimal effects. Bibliography of 15 items.

E. N. Harvey, Jr.

Text. Research J. Apr. 1947

Screen Printing

Screen printing of rayons by the urea process. Anon. *Silk J. Rayon World* 21, 34–6 (Feb. 1946).

Details of the urea screen-printing process are discussed with special reference to selection of dyes and of thickening agents, printing paste formulas, and steaming operations.

Text. Research J. Apr. 1947 R. K. Worner

Weakening of Rayon by Printing

Weakening of rayon fibers by printing and mordanting. A. Franken. *Jentgen's Kunstseide u. Zellwalle* 22, 300 (1940); *Chimie & industrie* 47, 239 (1942); cf. *C.A.* 32, 361[9] (through *Chem. Abstr.* 40, 7637[9] (Nov. 20, 1946)).

A general discussion of the causes of the weakening of printed and mordanted rayon.

Text. Research J. Apr. 1947

Steam Accumulator

The steam demand for dyeing. W. Goldstern. *J. Soc. Dyers and Colourists* 62, 301–7 (Oct. 1946).

The difficult problem of fluctuating steam demand by the dyehouse, more serious because of the necessity of fuel economy, is said to be efficiently solved by heat storage in a steam accumulator which serves as an elastic connection between the boiler and the dyehouse. The high installation cost may be balanced by fuel savings within a short period. Theoretical and practical considerations in the use of steam for dyeing are discussed; closed machines for piece dyeing showed a steam saving of 21.5%.

K. S. Campbell

Text. Research J. Apr. 1947

American Dyestuff Industry

Entire dyestuff industry developed since World War I. A. B. Brunier. *Textile World* 96, 106, 107 (Dec. 1946).

Traces the development of dyemaking in this country from 1919 to the present.

H. J. Burnham

Text. Research J. Apr. 1947

German Dyestuff Developments

Dyestuff developments in Germany during World War II. Miles A. Dahlen. *Am. Dyestuff Reptr.* 35, 119–23 (Mar. 11, 1946).

A paper giving briefly the more important information obtained by the chemists of the textile team of O.C.Q.M. consultants in Germany.

J. A. Woodruff

Text. Research J. Apr. 1947

Friction of Wool Fibers

Friction between keratin surfaces as affected by some shrink-proofing treatments. M. Lipson and P. Howard. *J. Soc. Dyers and Colourists* 62, 29–32 (Jan. 1946).

The differential frictional effect (D.F.E.) and the coefficient of friction values were obtained for wool fibers sliding on keratin rods (cattle horn) while both materials were wet with a solution of soap and sodium carbonate. Various shrinkproofing pretreatments were given to the wool and the keratin.

J. A. Woodruff

Text. Research J. Apr. 1947

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Asbestos-Rayon Blends

Rayon in the spinning of asbestos. Howard E. Shearer. *Text. Mercury and Argus* 115, 999–1000 (Dec. 27, 1946).

A discussion of recent developments in the use of viscose rayon staple as a carrying fiber in asbestos roving, yarn, and fabrics. Opening, blending, carding, and spinning are discussed.

H. J. Burnham

Text. Research J. Apr. 1947

Fibers

Relaxation effects in stretched cellulose model filaments. I. Relaxation of retractive force. J. J. Hermans. *Rec. trav. chim.* 65,

624–7 (Sept. 1946) (in English) (through *Bull. Inst. Paper Chem.* **17**, 229 (Jan. 1947)).

If cellulose model filaments are stretched at a moderate rate and then kept at constant length, the retractive force relaxes to a finite value, which is roughly one-half of the initial force at the moment relaxation sets in. Neither this initial force before nor the final force after relaxation is dependent on whether the fiber is stretched to the elongation studied in subsequent stages or directly.

Text. Research J. Apr. 1947

Relaxation effects in stretched cellulose model filaments. II. Relaxation of double refraction. D. Vermaas. *Rec. trav. chim.* **65**, 628–32 (Sept. 1946) (in English) (through *Bull. Inst. Paper Chem.* **17**, 229 (Jan. 1947)).

Highly swollen fresh cellulose model filaments when kept at constant length after having been stretched show an increase in double refraction and a decrease in degree of swelling with time. Reswollen filaments exhibit a decrease in double refraction at relatively low stretch and an increase at high elongation, the degree of swelling remaining constant in the former case and decreasing in the latter. A tentative explanation is given for these variations in double refraction. 11 footnotes.

Text. Research J. Apr. 1947

Properties of Ramie

Ramie fiber. Its properties and textile qualities. Olivier Roehrich and Bùi-Xuân-Nhuân. *Agron. trop.* **1**, 261–89 (1946); cf. *C.A.* **39**, 5082[8] (through *Chem. Abstr.* **41**, 289*g* (Jan. 10, 1947)).

White ramie (*Boehmeria nivea*), which grows in temperate zones, and the tropical green ramie (*B. utilis*) produce fiber in the cortex of their stems. The fiber is of best quality when the lower part of the stem has begun to turn brown. Microscopic examination discloses fiber lengths ranging from 55 to 330 mm., averaging 129 mm., with equal frequency of all lengths between 90 and 200 mm.; average widths of 55 μ (but greater for white than for green); cross-section thicknesses ranging from 20 to 60 μ, averaging 40 μ. The fibers are slightly flattened and unicellular, with cell walls of 7–15 μ, and a lumen of about 15% of the cross-section area. They show knots at regular intervals and characteristic lengthwise and spiraling striae. The following weight % of whole cellulose, pectin (as galacturonic acid monohydrate), pentosans, ash, and lipides are, respectively (*cf.* Bertrand and Brooks, *C.A.* **32**, 3145[4]; Gomez and Concepcion, *C.A.* **34**, 889[8]; Ramiro, *C.A.* **34**, 3922[1]; Ehrlich and Haensel, *C.A.* **30**, 2998[5]; Whistler, Martin, and Harris, *C.A.* **34**, 1479[7]): crude ramie cortex (rhea): 50–60, —, 7.2–8.5, 10.94, 1.06; decorticated ramie (China-grass): 75–80, 6.1, 3.8–3.94, 4.84, 0.19; fiber degummed by K_2CO_3: 84.60, 0.5–1.0, 0.87, 0.19, 0.17; degummed, bleached fiber: 99–9.5, —, 0.77, 0.15, 0.14. The cellulose consists of 97.00% α- and 2.88% β- and γ-cellulose. The fiber is (qualitatively) free of lignin and coloring matter. It holds 7.5–8% moisture at 20° and 65% R.H. Ramie is stable to boiling H_2O, steam, dilute hot alkali, and dilute cold acids, but is attacked by concentrated alkali, dilute hot acids, and concentrated acids. A sample of commercial fibers had an average fiber length of 159 mm., but by a weight method 148–150 mm., 60% of the fibers being above 150 mm. The fineness of ramie, measured as N_m (metric number, or 1,000 m./kg.), ranges from 1.620 to 3.500, with a maximum at 2.000–2.500 (*cf.* J. A. Colin, *Industrie textile* **48**, 82–5, 147–9, 210–1, 274, 400–1 (1931); Staudinger and Reinecke, *C.A.* **33**, 8414[3]; Meredith, *C.A.* **39**, 5080[8])—i.e., it is coarser than cotton but finer than linen. The dynamometer breaking strength of single fibers (10-mm. fiber segments, N_m 1.900) ranges from 15 to 45 g., average 32.2 g. From this and the N_m, the breaking length of the fiber is calculated to be 61.2 km. When strands of fibers are tested, breaking lengths of the best grades were 55–60 km.; of inferior grades, 40–50 km. The wet breaking strength of a combed commercial ramie is 35 g., and of the dry fiber 30.9 g., an increase of 15.1% (wetted with water containing Nekal C4B). Stress-strain curves of fibers taken in the Chevenard micro-dynamometer (cf. *Compt. rend. trav. lab. com. gén. org. ind. text.* **1**, 141–52 (1943)) reveal elongations at break of 3.7–5.3% (5.8% for mercerized ramie), average 4.5%; and breaking strengths of 15–60 g. (39 g. for mercerized ramie), average 38.7 g.; mercerization increases the fiber's resistance to sudden stress. The suppleness of a ramie fiber, as twists/m. on torsion (10 cm. or 0.01 g. samples, N_m = 10, 50-g. load), is 641, and the torsion coefficient ((twists/m.)/$\sqrt{N_m}$) is 203 for a fiber of 55 km. breaking length. Knotting reduced the fiber's breaking strength from 31 to 17.1 g., or 44.8%. Therefore, ramie is a little stiffer than linen. The color (equal to that of very pale unbleached cotton), density (1.5, corrected for lumen, 1.2), luster (equal to that of silk, lower when mercerized), normal moisture content, and "coolness" of ramie are also discussed. For textile test methods, see F. Maillard and O. Roehrich, *Comp. rend. trav. lab. com. gén. org. ind. text.* **1**, 9–12 (1943). The literature on ramie, linen, and cotton fibers is reviewed for comparison.

Text. Research J. Apr. 1947

Shrinkage of Wool

Effect of hydrogen peroxide in the presence of copper sulfate on the shrinkage of wool. J. Anderson. *Nature* **158**, 554 (Oct. 1946).

It is shown that the shrinkage of wool samples is reduced by treatment with hydrogen peroxide in the presence of copper sulfate at pH 4.2. A further reduction was obtained by additional treatment with dilute sulfuric acid solution. The directional frictional effect was not affected. Treated fibers were more easily extensible, yet the ability to recover from deformation was not impaired. R. W. Eyler

Text. Research J. Apr. 1947

Syton

Colloidal silica increases strength of cotton yarns when applied to fiber before spinning. Anon. *Textile Age* **11**, 78, 80–1 (Jan. 1947).

Results of tests conducted by the Research Division of the National Cotton Council indicating significant increases in cotton yarn strength when cotton is treated with silica in colloidal dispersion prior to spinning. The material used was Syton. Card or drawing sliver is treated in a continuous, single-strand operation and concentration of silica is 0.25 to 5%, with yarn strength increase dependent on concentration in this range. Experimental apparatus consists of an immersion bath, a set of squeeze rolls, an infrared-drying tunnel and a coiler he..d for packaging.

H. J. Burnham

Text. Research J. Apr. 1947

Mothproofing Wool

Protection of wool against the attack of the larvae of clothes moths. Henri Wahl. *Chimie & industrie* **53**, 167–70 (Mar. 1945) (in French) (through *Bull. Inst. Paper Chem.* **17**, 269 (Jan. 1947)).

The organisms alluded to are the larvae of *Tineola biselliella* (clothes moth) which cause enormous destruction to woolen fabrics. Their control by physical and chemical means is discussed in some detail. These include the use of certain Eulan (containing 65.5–65.7% carbon, 4.5–4.6% hydrogen, 22.8–23% chlorine, and 6.9–7% phosphorus), and the organic compound known as "Mitin FF." Contact poisons (DDT and Gammexane) are also treated briefly. A number of references, largely to patent literature, are included.

Text. Research J. Apr. 1947

Curtain Fabrics

A comparative study of cotton and rayon glass curtain fabrics. Florence E. Petzel. *Ohio Agr. Expt. Sta. Bull.* **645**, 30 pp. (1943) (through *Chem. Abstr.* **41**, 292*a* (Jan. 10, 1947)).

Various fabrics were evaluated for sizing, finishing, breaking strength before and after laundering, and for breaking strength and fading after exposure to sunlight, light at a north window, and to a Fade-Ometer. In so far as possible the tests conformed to those of Committee D-13 of the A.S.T.M. The results are tabulated and discussed.

Text. Research J. Apr. 1947

Pneumatic Scavenger Roll

The Thoma cleaner. Anon. *Text. Weekly* **39**, 170, 172 (Jan. 24, 1947).

A description of a pneumatic vacuum cleaning system to replace the conventional scavenger rolls on spinning frames. A suction pipe runs the length of the frame beneath the front bottom roll in the position normally occupied by the scavenger roll with a hole immediately beneath each point at which yarn is delivered. When an end breaks, the suction hole captures the floating untwisted yarn and sucks it to a control air passage under the creel and thence to a filter box at the end of the frame. Advantages claimed are: fewer ends down, more spindles per operator, a cleaner room, and softer reworkable waste. H. J. Burnham

Text. Research J. Apr. 1947

Warp Beams

Small cores in warp beams are not unqualified benefit. R. J. Demartini. *Textile World* **97**, 133, 184, 186 (Jan. 1947).

It is shown that a beam 41 in. in diameter with a 10-in. core will hold the same yardage of yarn or cloth as a beam 40 in. in diameter with a 4-in. core. The advantages of using larger cores are discussed from a drive standpoint. To maintain constant surface speed a motor capable of a 4 to 1 speed range by field control is suitable when the larger core is used, whereas to get the 10 to 1 speed range required with the smaller core, armature voltage control would be necessary, complicating the control and increasing the cost. H. J. Burnham

Text. Research J. Apr. 1947

New Woolen Card

Improved woolen card holds many features. Anon. *Am. Wool and Cotton Reptr.* **61**, 11, 13 (Feb. 27, 1947).

A woolen card is described which has six sets of workers and strippers, a fancy and a doffer, that work against the bottom of a 96-in. cylinder and are said to do the work of a breaker card, while 11 sets of workers and strippers on the top of the same cylinder act as the finisher. A Bramwell feed and tape condenser set are at the same end of the machine while the stock is brought out, doubled onto an apron, and fed back through intermediate feed rolls at the other end. Substantial saving is made in required floor space. H. J. Burnham

Text. Research J. Apr. 1947

Worsted Spinning

New worsted spinning on American system. Robert J. McConnell. *Am. Wool and Cotton Reptr.* **61**, 11, 12 (Feb. 20, 1947).

An address giving details of machines and organization in spinning 36s to 40s worsted yarns from 56s to 64s worsted tops on modified cotton machinery. Yarn quality is said to compare favorably with that of yarns spun on the French system at a saving of about $10 per spindle per yr. on a 2-shift basis.

H. J. Burnham

Text. Research J. Apr. 1947

O.T.S. REPORTS*

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Women's Slacks

Report of test of slacks, cotton, khaki, women's; shirts, cotton, khaki, women's. (Project T-514; QMB Test 1597.) U. S. Quartermaster Board. PB 49517, Nov.

* Copies of these reports may be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Orders should be accompanied by check or money order payable to the Treasurer of the United States.

1945; 27 pp.; microfilm, $1.00—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* **4**, 311 (Jan. 24, 1947)).

The test was conducted to determine the adequacy and functional suitability of shirts and slacks made from twill, poplin, seersucker, and herringbone twill fabrics, with respect to fit, comfort, and appearance when worn for varying activities under prevailing summer climatic conditions. It was recommended that: (1) the 4 types of shirts and slacks be considered satisfactory for women's summer wear in the following order of preference: poplin, twill, seersucker, and HBT shirts and slacks; (2) the white cotton panties be considered satisfactory for issue for summer wear, and superior to rayon; (3) the white cotton undershirt be considered satisfactory; (4) both the WAC summer hat and cotton khaki garrison cap be considered satisfactory for summer wear, and the bandanna be considered unsatisfactory; (5) the women's field boots be considered satisfactory for wear in the field and the field shoes and leggings be considered as unsatisfactory. Photographs, graphs, table, and questionnaires are included.

Text. Research J. Apr. 1947

Report of test of slacks, women's, winter, dark OD. (Project T-530; QMB Test 1599.) U. S. Quartermaster Board. PB 49801, Feb. 1946; 9 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **4**, 311 (Jan. 24, 1947)).

A test was conducted to determine the relative adequacy of the design and fit of the modified as compared with the present standard winter, dark OD women's slacks. It was recommended that: (1) the modified design be considered superior to standard slacks and that there be incorporated into the modified slack the one superior feature of the standard design—namely, the wider waistband; (2) slacks be made in one length only, based on the present tariff length of standard slacks with the addition of approximately 2 in. to the hem; (3) it be considered unnecessary to include a size 20 in the tariff of sizes. Exhibit B presents chart showing average measurements of standard and modified slacks. There is no exhibit A.

Text. Research J. Apr. 1947

Women's Rayon Stockings

Report of test of stockings, rayon, women's. U. S. Quartermaster Board. (Project T-527; QMB Test 1623.) PB 52146, Nov. 1945; 12 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **4**, 693 (Feb. 21, 1947)).

Tests described in this report were made to determine the adequacy of fit, appearance, and comparative wearing qualities of women's rayon stockings made over specifications PQD 206B (100 den., 45 gage, Type I), and experimental stockings (75 den., 45 gage, Type II, and 75 den., 51 gage, Type III), when worn for regular and off-duty wear. Types I and III were considered equally satisfactory as far as durability was concerned and superior to Type II in this respect. The color (Serene), sheerness, and appearance of Types II and III were considered equally satisfactory for off-duty wear and superior to Type I in these respects. It is recommended that experiments be conducted to establish methods of dyeing and laundering to eliminate color fading. Exhibits B to E contain graphs and photographs. There is no exhibit A.

Text. Research J. Apr. 1947

Army Shirts

Report of test of shirts, officers'. (Project T-495; QMB Test 1609.) U. S. Quartermaster Board. PB 49524, June 1945; 18 pp.; microfilm, $1.00—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* **4**, 310 (Jan. 24, 1947)).

Tests were conducted to determine the suitability of 5 experimental types of officers' shirts of revised design with respect to fit, comfort, and appearance, and to ascertain whether they overcome such common criticisms of the present standard officers' shirts as largeness at the waist and chest, tightness across the shoulders and back, and bulkiness of the shirttails. It was recommended that: (1) the design of the experimental shirts, officers' (types 2, 3, 8, 9, and 10), be considered slightly superior to the design of the standard shirts, officers' (types 1 and 7), but that consideration be given to specified modifications; (2) rayon collar and yoke linings be considered desirable features on officers' tropical worsted shirts; (3) the officers' shirts types 9 (wool flannel) and 10 (tropical worsted) be considered superior to the officers' shirts types 7 and 8 (tropical worsted) with respect to launderability; (4) the collars of the shirts, officers', types 1 and 2 (8.2-oz. twill), be considered unsatisfactory with respect to resistance to shrinkage after laundering. Type 3 (poplin) was preferred to the type 2 (8.2-oz. twill) from the standpoint of comfort and appearance. Photographs, and graphs showing shrinkage after laundering and pressing, are included.

Text. Research J. Apr. 1947

Report of test of shirts, enlisted men's. (Project T-499; QMB Test 1622.) U. S. Quartermaster Board. PB 49527, July 1945; 19 pp.; microfilm, $1.00—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* **4**, 310 (Jan. 24, 1947)).

The objective of the test was to determine the suitability of 6 experimental types of enlisted men's shirts of revised design (3 types of cotton shirts and 3 types of wool flannel shirts) with respect to fit, comfort, and appearance; and to ascertain whether the experimental shirts overcome criticisms of the present standard shirts with respect to largeness of the waist and chest, tightness across the shoulders and back, bulkiness of the shirttails, and lack of pencil slot in the pockets. It was recommended that: (1) the type 2 khaki shirt (8.2-oz. cotton, uniform twill) and the type 7 shirt (10.5-oz. wool flannel) be considered

as meeting the greatest number of military requirements and soldier preferences, and be considered superior to all the standard shirts and the remaining experimental shirts of their respective fabrics; (2) certain specified construction features be considered desirable; (3) shirts be manufactured with sufficient oversizing of the collars and sleeve lengths to compensate for resultant shrinkage at those locations. Tables and photographs are included.

Text. Research J. Apr. 1947

Wool Socks

Report of test of socks, wool, heavy, experimental. U. S. Quartermaster Board. (Project T-373; QMB Test 1476.) PB 52144, June 1945; 12 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **4**, 693 (Feb. 21, 1947)).

Tests were conducted to determine the relative merits with respect to durability, comfort, and launderability of 3 experimental types of yarn constructions for use as substitutes for the standard yarn construction in the manufacture of heavy wool socks, and to evaluate the effect of shrinkproofing on socks of each type of yarn. Types 2 (single-end untreated), 4 (standard Hypol-treated), and 5 (single-end Hypol-treated) socks were superior to the type 1 (standard untreated) socks with respect to durability, whereas the other experimental types tested—types 3 (core yarn untreated), 6 (core yarn Hypol-treated), 7 (Canadian untreated), and 8 (Canadian shrink-resistant-treated)—were inferior in this respect. Types 2, 4, and 5 were satisfactory with respect to comfort whereas the other types were unsatisfactory. The Hypol shrinkproof treatment was considered effective in reducing shrinkage and moderately effective in increasing the life span of heavy wool socks of standard yarn construction, but not materially effective in increasing life span of socks of single-end yarn construction. Exhibits C to F contain charts, graphs, and table. There is no exhibit A.

Text. Research J. Apr. 1947

Shrink-Resistant Shirts

Report of test of shirts, knit, OD, shrink-resistant. (Project T-480; QMB Test 1605.) U. S. Quartermaster Board. PB 49526, Apr. 1945; 11 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **4**, 310 (Jan. 24, 1947)).

Field tests were conducted to determine the optimum degree of shrink-resistance to impart to knit shirts, OD. It was concluded that: (1) shirt type 4 (labeled as 60% shrinkage control) is satisfactorily resistant to felting and shrinkage after 5 launderings, whereas shirts type 1 (untreated), type 3 (labeled as 20% shrinkage control), and type 5 (labeled as 80% shrinkage control) are unsatisfactory in this respect; (2) indications are that the 60% shrinkage control treatment may have a deleterious effect on the wearing qualities of the fabric of the shirt. Diagram showing measurements, table, and graphs are included in exhibits B–D. No exhibit A.

Text. Research J. Apr. 1947

Shrink-Resistant Sweaters

Report of test of sweaters, high neck, shrink-resistant. U. S. Quartermaster Board. (Project T-524; QMB Test 1653.) PB 52149, June 1945; 11 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **4**, 693 (Feb. 21, 1947)).

Two types of shrink-resistant-treated sweaters were tested to compare them with the standard untreated sweater in order to provide a means by which the shrinkage resulting from laundering and wear could be reduced, and to ascertain by preliminary study what degree of shrink-resistance, as measured by laboratory methods, represents a satisfactory field resultant. It was concluded that untreated sweaters are unsatisfactory with respect to resistance to shrinkage and felting resulting from laundering; that sweaters treated by the Freney Lipson (50% area shrinkage control) and the chlorinated (100% area shrinkage control) methods are superior to the untreated sweaters and do not cause any apparent skin irritation, but are inadequate with respect to providing a means of controlling dimensional stability and retaining original properties of wool fabric after laundering. Exhibit A is missing, but exhibits B–E present table, photographs, and graphs.

Text. Research J. Apr. 1947

Wool Underwear

Report of test of underwear, wool, sizing of. U. S. Quartermaster Board. (Project T-521; QMB Test 1660.) PB 52160, July 1945; 13 pp.; microfilm, $1.00—photostat, $1.00 (through *Bib. Sci and Ind. Reports* **4**, 694 (Feb. 21, 1947)).

Tests described in this report were made to determine the adequacy of fit of 2 lots of 50% wool undershirts and drawers which had been altered at the time of manufacture to simulate the longitudinal dimensional changes resulting from shrinkage due to laundering, with a view toward establishing a table of minimum wearable measurements for resizing wool underwear. Underwear altered to conform with measurements set forth in Tables I–IV was compared with standard wool underwear. Table I was considered satisfactory and Table III unsatisfactory except for men 5 ft. 8 in. in height or less as tables of minimum wearable measurements for resizing undershirts. Table II and Table IV were considered unsatisfactory, except for men with inseams of 28 in. or less, as tables of minimum wearable measurements for resizing drawers. Exhibits D–F contain photographs. Exhibits A–C containing tables are not included.

Text. Research J. Apr. 1947

Wind-Resistant Clothing

Test of clothing, battle (windproof shell and pile liner). Second report. U. S. Quartermaster Board. (Project T-119.) PB 50776, Feb. 1943; 20 pp.; microfilm, $1.00—photostat, $2.00 (through *Bib.*

Sci. and Ind. Reports **4**, 694 (Feb. 21, 1947)).

Three types of cotton jackets and 3 types of cotton trousers were used in these tests to determine the comparative merit, warmth, comfort, and wind-resistance of various items of battle clothing for active use in the field. Tests were made in weather below and above 30°F. The findings indicate that the battle clothes (cotton shell and pile liner) provide greater warmth than the other combinations of winter clothing which were tested at Camp Lee. The freedom of movement and general utility of the battle clothes for combat action would be increased if certain specified changes in design were incorporated. Type B trousers were found to be more satisfactory than types A or C. The pile liners are not suitable for frequent field launderings. Additional protection against cold and wind is necessary at the neck of the pile pullover jacket. A waist adjustment is necessary in the pile trousers to allow for shrinkage and a more secure fastening is needed at the ankle. The water-repellency of the cotton shells is unsatisfactory after laundering. Indications are that the strength of the cotton shells is not great enough to support the strain imposed by full-cargo pockets. It is recommended that battle garments incorporating recommended changes in design be made for further test. Exhibits B–D contain drawings, photographs, and table. There is no exhibit A.

Text. Research J. Apr. 1947

MISCELLANEOUS

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Adhesives

Sizes and adhesives made from synthetic resins. Am. Matagrin. *Papeterie* **68**, 167–70; 201–3, 205–6; 239–41; 266–7, 269–70 (June–Sept. 1946) (in French) (through *Bull. Inst. Paper Chem.* **17**, 217 (Jan. 1947)).

The author discusses the colloidal behavior, adhesive properties, and other characteristics of thermoplastic and thermosetting synthetic resins. The phenol-aldehyde and urea-formaldehyde resins, the glyptals and alkyd resins, vinyl resins, polyacrylates, and coumarone and indene resins are treated briefly. A section is devoted to the manufacture and general properties of adhesives made from synthetic resins, given largely in terms of American practice. The use of hardeners, fillers, extenders, solvents, and pigments is outlined. The author describes the preservation of adhesives during storage, preparation for immediate use, amounts to be used for a specific purpose, time required for application, water content, and surface properties of materials to be glued, temperature of operation in the case of cold-setting and hot-press adhesives, and pressures exerted during the gluing process. The glues discussed at some length are those containing hot-press phenol resins, resorcinol-formaldehyde resins, urea or thiourea-aldehyde resins, melamine resins, etc. The uses of such adhesives in the paper and board industries are outlined.

Text. Research J. Apr. 1947

British Cotton Industry

The three reports. Allan Draper. *Text. Weekly* **39**, 66, 68, 70, 72, 114, 116, 118 (Jan. 10, 17, 1947).

An address dealing with the recommendations of the "Platt," "Evershed," and "Schuster" reports on the British cotton industry. Several separate recommendations are summarized and each one commented on in turn. H. J. Burnham

Text. Research J. Apr. 1947

Files and Filing

A modified Holmstrom system of documentation. Archibald G. Clement and Robert H. S. Robertson. *J. Documentation* (Aslib) **1**, 217–21 (Mar. 1946) (through *Bull. Inst. Paper Chem.* **17**, 169 (Dec. 1946)).

The principle adopted for the Holmstrom system of documentation is similar to the decimal classification, but words are used instead of numbers; also, instead of the analysis of each subject being standardized it is "thought out" as the index grows. The authors explain their modifications of this system, illustrating them with typical examples. Such a system is quickly compiled and easily used, and is convenient where there is no trained librarian. Patents, reprints, newspaper clippings and photographs, reports, abstracts, and notes are adaptable to this system.

Text. Research J. Apr. 1947

Moot points in the filing of business papers. J. E. Holmstrom. *J. Documentation* (Aslib) 2, 1–7 (June 1946) (through *Bull. Inst. Paper Chem.* **17**, 169 (Dec. 1946)).

The author emphasizes the need of well-trained personnel in order to do a really good job of filing. He discusses filing under the following topics: need for "unity of theme," a term which is not used as a synonym for "subject"; starting of new files, which becomes necessary whenever a new theme emerges, and which involves defining the scope of future contents of the file and identifying the file by a title, number, or symbol under which it may be known; indexing of the contents of files; binding and physical make-up of files; weeding and transferring of file material to archives; departmental vs. centralized filing; lending, circulation, and recall of files; minuted files; size of files; filing discipline; training of personnel; and nomenclature.

Text. Research J. Apr. 1947

The indexing and filing of correspondence in the laboratories of J. Lyons & Co. Ltd. Marian Shaw. *J. Documentation* (Aslib) **2**, 17–20 (June 1946) (through *Bull. Inst. Paper Chem.* **17**, 169 (Dec. 1946)).

This is a detailed account of the methods of handling correspondence in this English laboratory. It is presented with the thought that other organizations might be interested in comparing this system with, and possibly revising, their own. The author stresses the importance

of having capable persons to do filing and deplores the general and false idea that correspondence filing is a job of little importance.

Text. Research J. Apr. 1947

Nuclei Formed by Fission

Nuclei formed in fission: decay characteristics, fission yields, and chain relationships. Issued by the Plutonium Project. *Rev. Modern Phys.* **18**, 513–44 (Oct. 1946).

A survey and tabulation with extensive references. T. J. Dietz

Text. Research J. Apr. 1947

Olefins

Chemicals from olefins. H. D. Axe. *J. Soc. Dyers and Colourists* **62**, 129–32 (May 1946).

A review of the sources and properties of olefins obtained from petroleum. J. A. Woodruff

Text. Research J. Apr. 1947

Patents

What is invention? Paul Wengraf. *Textil-Rundschau*, 4–10 (July 1946).

The concept of invention is extremely difficult to define, and when defined in accordance with the patent laws of one nation the definition is not necessarily correct in other nations. For example, under the ruling that imparting ductility to tungsten is not invention it seems probable that imparting a similar property to cellulose in the manufacture of rayon is also not invention. Therefore, the manufacture of protein fibers from casein or like sources is not invention. There is some question as to whether pigment delustering of rayon would be regarded as an invention in view of the much older art of incorporating metal compounds in rayon filaments in the manufacture of gas mantles. Even when the concepts of invention and patentability are separated it is still difficult to define invention, partly because the boundary between practical utility and artistic merit is not sharply defined.

Text. Research J. Apr. 1947

Petroleum Products

Petroleum in the textile industry. R. B. Baillie. *Textile J. Australia* **21**, 300–1 (1946) (through *Chem. Abstr.* **41**, 1107*a* (Feb. 20, 1947)).

A discussion of petroleum products suitable for use in the textile industry as lubricants, detergents, wetting agents, etc.

Text. Research J. Apr. 1947

Classification of Plastics

A classification of plastics. H. Bouman, R. Houwink, and C. P. A. Kappelmeier. *Oil Color Trades J.* **110**, 634, 636 (1946) (through *Chem. Abstr.* **41**, 309*e* (Jan. 10, 1947)).

Communication No. 63 from Plastic Institute, Julianclaan 134, Delft, Holland. The main classifications, with the principal subdivisions are as follows: (A) chemically modified macromolecular materials (*I*) based on natural rubber, (*II*) based on cellulose, (*III*) based on starch, (*IV*) based on protein, (*V*) based on natural resins, (*VI*) based on oils, (*VII*) based on alginate, etc.; (B) condensation products (*I*) based on PhOH and CH_2O, (*II*) based on PhOH and aldehydes other than CH_2O (e.g., furfural), (*III*) based on aldehydes or ketones only, (*IV*) based on nitrogenous products, (*V*) based on polybasic acids and polyhydric alcohols, (*VI*) chlorinated hydrocarbons, (*VII*) thioplasts, (*VIII*) silicones; (C) polymerization products (*I*) based on coumarone and indene, (*II*) based on allyl esters, (*III*) based on other monomers with one double bond, (*IV*) based on monomers with two double bonds; (D) plastics of which the chemical composition is unknown.

Text. Research J. Apr. 1947

Glass-Reinforced Plastics

Glass-reinforced plastics. E. H. G. Sargent. *Ind. Chemist* **22**, 665–70 (1946) (through *Chem. Abstr.* **41**, 619*f* (Jan. 20, 1947)).

A review with 18 references.

Text. Research J. Apr. 1947

Delustered Rayon

Abrasive effect of delustered rayons on steel needles and card wire. R. Lasse and Jakob Cunz. *Textil-Rundschau*, 10–14 (July 1946).

Rayons delustered with titanium dioxide can cause severe wear of knitting machine needles and card fillet wires. Examples of delustered rayons and some of their effects on needles and wires are illustrated by photomicrographs. Rayon manufacturers consider abrasive effect, along with delustering effect, as a factor in selecting the best particle size for the delustering pigment. Phase-contrast photography is useful in these studies. Dark-field photography is also an aid in bringing out fine pigment particles in a fiber.

Text. Research J. Apr. 1947

Rotproofing

The effect of weathering on rotproofed cordage. C. H. Bayley and M. W. Weatherburn. *Am. Dyestuff Reptr.* **35**, 218, 235–6 (May 6, 1946).

Seven months of exposure on a roof were given to cordage samples of treated and untreated cotton, hemp, Manila, sisal, and a wartime substitute. The presence of copper naphthanate and copper oleate in amounts of the order of 0.1 and 0.5% copper does not result in increased actinic degradation; the untreated samples showed greater loss; the presence of pine tar in the treatments with the copper had no effect; and the presence of wax reduced the otherwise substantial losses of copper during weathering. J. A. Woodruff

Text. Research J. Apr. 1947

Vacuum Engineering

New developments in vacuum engineering. Robert B. Jacobs and Herbert F. Zuhr. *J. Applied Phys.* **18**, 34–48 (Jan. 1947).

The development of leak detection techniques as applied for the separation of U^{235} at the Manhattan Project's Gaseous Diffusion Plant is discussed. New apparatus and techniques are described.

Text. Research J. Apr. 1947 T. J. Dietz

Russia and Textiles

Russia and textiles. H. C. Kershaw. *Text. Recorder* **64**, 62 (Jan. 1947).

A brief report of textile developments in Russia. The extent of production of raw cotton and statistics on manufacture are given for the period 1913 to 1938.

Text. Research J. Apr. 1947

Surface-Active Compounds

Surface-active compounds. H. H. Mosher. *Am. Dyestuff Reptr.* **35**, 168–73 (Apr. 22, 1946).

A discussion of the chemical structure and properties of surface-active compounds and a review of the textile uses of such products.

J. A. Woodruff

Text. Research J. Apr. 1947

The Technician

The technician in industry. A. W. Bayes. *Text. Weekly* **38**, 984, 986 (Nov. 22, 1946).

A lecture outlining the duties of the ideal technician, stressing the necessity of keeping accurate and adequate records and the use of statistics in analyzing results. A technician's job is outlined as: measurement of quality, machine behavior, and working conditions, development of machine processes, and contact with machine makers, research laboratories, and other technicians. H. J. Burnham

Text. Research J. Apr. 1947

PATENT REFERENCES

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Bonded Webs

Fibrous structural material and method and apparatus for making same. Joseph Goldman (to Fibre Products Laboratories, Inc.). U. S. 2,407,548 (Sept. 10, 1946).

A process is described for treating ribbon lap with resin solutions to form a bonded web of oriented fibers.

Text. Research J. Apr. 1947 A. R. Martin

Casein Extraction from Seeds

Method for the extraction of casein from seeds. Robert Louis Wormell (to Courtaulds Limited). U. S. 2,406,650 (Aug. 27, 1946).

Alkaline solution of acetone in water is used. A. R. Martin

Text. Research J. Apr. 1947

Decorticating Machine

Decorticating apparatus. Karl Kaiser (to California Central Fibre Corporation). U. S. 2,402,-634 (June 25, 1946).

A portable decorticating machine for flax suitable for use in the field.

Text. Research J. Apr. 1947 A. R. Martin

Decorticating machine. John S. Reeves. U. S. 2,404,457 and 2,404,458 (July 23, 1946).

A decorticating machine for Agave-type fibers. A. R. Martin

Text. Research J. Apr. 1947

Apparatus for treating fibrous materials. Charles R. Carpenter. U. S. 2,405,401 (Aug. 6, 1946).

A decorticating machine for hemp, sisal, flax, etc. A. R. Martin

Text. Research J. Apr. 1947

Crimped Filaments

Resilient filaments. Frederick G. Dodge (to Celanese Corporation of America). U. S. 2,408,381 (Oct. 1, 1946).

A process for crimping acetate staple. Fibers are treated with 70–90% alcohol, the excess alcohol removed, and the fibers then treated with water at 150–160°F.

Text. Research J. Apr. 1947 A. R. Martin

Production of Staple from Filaments

Yarn producing apparatus. Mario Ottomano (to American Safety Razor Corporation). U. S. 2,406,-626 (Aug. 27, 1946).

A gill box faller bar. A. R. Martin

Text. Research J. Apr. 1947

Finishing Treatment

Treatment of paper or textile fabrics. William Charlton, Stanley Graham Jarrett, and Eric Everard Walker (to Imperial Chemical Industries Limited). U. S. 2,406,-453 and 2,406,454 (Aug. 27, 1946).

Fabrics are treated with acrylic acid esters which are subsequently polymerized to yield a wash-fast finish. A. R. Martin

Text. Research J. Apr. 1947

Improvement of Synthetic Proteins

Method of treating synthetic proteinaceous materials. Francis Clarke Atwood (to National Dairy Products Corporation). U. S. 2,408,026 and 2,408,027 (Sept. 24, 1946).

A treatment for synthetic protein fibers to improve resistance to hot water, acids, and alkalies, and to improve dyeing properties is described. The fiber is hardened with formaldehyde and then acetylated.

A. R. Martin

Text. Research J. Apr. 1947

Chemically Modified Wool

Chemically modified wool. David Malcolm McQueen (to E. I. du Pont de Nemours & Company). U. S. 2,406,958 (Sept. 3, 1946).

A wool of reduced tendency to shrink is obtained by treatment in dry ether with styrene or acrylonitrile in the presence of iodine.

A. R. Martin

Text. Research J. Apr. 1947

Wool Treatment

Treatment of wool fibers. John Bamber Speakman and Thomas Barr (to Imperial Chemical Industries Limited). U. S. 2,406,-412 (Aug. 27, 1946).

Wool-containing textile is treated at 90–95°C with volatile vinyl monomer which polymerizes on the fibers. A. R. Martin

Text. Research J. Apr. 1947